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ABSTRACT

This document contains the following full and short papers on virtual laboratories, classrooms, and schools from ICCE/ICCAI 2000 (International Conference on Computers in Education/International Conference on Computer-Assisted Instruction): (1) "A Collaborative Learning Support System Based on Virtual Environment Server for Multiple Agents" (Takashi Ohno, Kenji Saito, Hajime Saitoh, and Takashi Maeda); (2) "A Constructivist Virtual Physics Laboratory" (Fu-Kwun Hwang); (3) "A Distributed Backbone System for Community-Based Collaborative Virtual Universities" (Qun Jin, Jingde Cheng, Hiroaki Ogata, and Yoneo Yano); (4) "A Flexible Transaction Model for Virtual School Environments" (Woochun Jun and Sukki Hong); (5) "A Virtual Classroom for Algorithms with Algorithmic Animation Support" (Jian Shyu Shyong, Yin Te Tsai, and R.C.T. Lee); (6) "Agent-Oriented Support Environment in Web-Based Collaborative Learning" (Tomoko Kojiri and Toyohide Watanabe); (7) "Building the Virtual Classroom for the New Millennium" (Chien-Chih Lee); (8) "Design and Implementation of a N-Tiered Heterogeneous Virtual School Administration System" (Huang Gooshyon); (9) "Developing an IT-Immersion Environment To Enhance Learning and Teaching in Design and Technology" (Ting Kau Lo, Wing Kee Au, and Wai Ming Yip); (10) "Development of the Web-Based Classroom System To Be Implemented by the Teachers" (Go Ota and Kanji Akahori); (11) "Models and Strategies for Promotion of Distance Learning in Primary Schools and High Schools" (Jia-Rong Jerome Wen, Chia Chin Li, and Jian Jie Dung); (12) "Monitoring and Verifying Mathematical Proofs Formulated in a Restricted Natural Language" (Peter Schmidt); (13) "Simulating Engineering Professional Practice Using an Interactive Web-Based Resource: A Virtual Engineering Consultancy Company (VECC)" (Robert M. Corderoy and Paul Cooper); (14) "The Status of Cyber University in Korea and Its Future Direction" (Sukhee Wang and Youngsil Kim); (15) "Two Types of Virtual School in INET Supported by Teacher's Group--Collaboration Type and Loosely Connected Type" (Shoichi Kinosita and Nobuyuki Arakawa); (16) "WALTZ: A Web-Based Adaptive/Interactive Learning and Teaching Zone" (Long-Chyr Chang, Heien-Kun Chiang, and Pi-Shin Wey); and (17) "Web-Based Subject-Oriented Learning Program on Geophysics for Senior High School" (Rong-Kuan Yang, Yi-Ben Tsai, and Shi-Jen Lin). (MES)

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Learning Societies in the New Millennium : Creativity, Caring & Commitments

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A Collaborative Learning Support System Based on Virtual Environment Server for Multiple Agents

Takashi OHNO* Kenji SAITO* Hajime SAITOH and Takashi MAEDA***
**Graduate School of Hokkaido Information University*
Ebetsu 069-8585, JAPAN
Tel: +81-11-385-4416 Fax: +81-11-384-0134
***Graduate School of Engineering, Hokkaido University*
Sapporo 060-8628, JAPAN
Tel: +81-11-716-2111(ext.6498)
E-mail:{t-ohno, maeda, ksaito }@do-johodai.ac.jp, hajime@complex.eng.hokudai.ac.jp

It is generally agreed that learning efficiency improves if the students find teaching/learning materials interesting. It is the same when we engage in collaborative learning with the use of computer networks. We take into consideration the collaborative learning environment that is suitable for each learner, the personality of the group and the knowledge levels of learners. We have been constructing a collaborative learning support system being developed on VESMA(Virtual Environment Server for Multiple Agents) system.

Keywords: **Collaborative Learning, Intelligent Agent, Virtual Environment**

1 Introduction

It is generally agreed that learning efficiency improves if the students find teaching/learning materials interesting. It is the same when we engage in collaborative learning with the use of computer networks. In other words, it is possible that the learner's interest and concern will be attracted if there is an intermediary who supports the learner with the idea of using the teaching/learning materials function as a learning object between the learner (user) and the learning object. And, it is very important to grasp the learner's mental state in collaboration with plural learners in a virtual environment like a computer networks. We take into consideration the collaborative learning environment that is suitable for each learner, the personality of the group and the knowledge levels of learners. We have been constructing such a learning support system as a part of our Virtual University project being built up on VESMA(Virtual Environment Server for Multiple Agents) system.

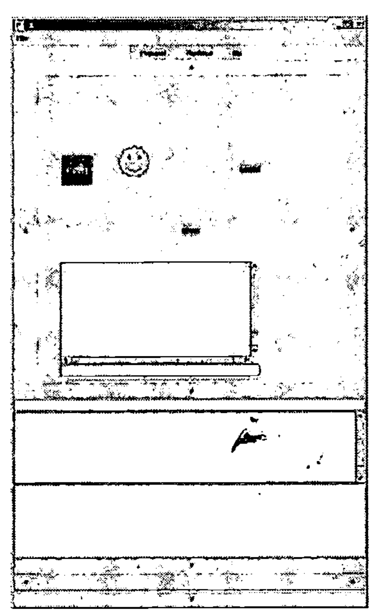

Fig. 1 Client of VESMA System

In the rest of the paper, we describe a general mechanism of VESMA system and its features in section 2. In section 3, we discuss on collaborative learning in such a virtual environment including some intelligent agents who support such learning. In section 4 and 5, we will discuss the supporting function of effective collaborative learning and the learning process in the collaborative learning support system. Concluding remarks and some future works are briefly described, in the last section,.

2 VESMA System

In this paper, we have been constructing a virtual environment using the VESMA system developed in the

Java language. This VESMA system provides the programming environment to simulate the virtual space which a lot of elements exchange the message and affect each other. This system has been used for an agent programming, the simulation of a physical/social phenomenon and a probabilistic network etc. by present.

2.1 Server-Client System The VESMA system is a system which consists of the server and the client, and contains user's avatar, the object and the agent that is in virtual environment in the server. The client displays an environment surrounding user(s), and interprets the inputs of the user, and let the avatar execute it. This system can be executable in all platforms, and translate an arbitrary object between server-client or server-server through a computer network, because this system uses the Java language.

The objects corresponding to the entrance can exist in a virtual space of the VESMA system, these objects are connected with another place of this server or other servers, and the user can move between the servers freely by accessing this entrance object.

2.2 Layered Structure A virtual space of the VESMA system can take the layered structure, as can be seen in the last paragraph of section 2.1. When a complex virtual space and a lot of rooms are made, it is very convenient to be able to make the layered structure for representing a spatial metaphor. For instance, layered structures such as the city, university, faculties, and laboratories can be represented.

2.3 Autonomous Object The object is static or passive in a usual educational virtual environment system, so it can answer to a user's request or reply to a messages, but it is difficult to realize an object which behaves actively. The object in VESMA system can behave with own thread by programming the object to send oneself the message. In other words, VESMA system supports making of an autonomous agent.

2.4 Simulation of Various Phenomenon The VESMA system is not only suitable as the educational virtual environment programming environment, but also suitable for the simulation of a physical phenomenon. Our collaborative learning support system on VESMA system can simulate a physical phenomenon as well. It is also possible that the user can experiment by operating the experiment tool in the virtual environment, and change the parameter and setting the experiment, and repeat the experiment trying and erring. These experiments are useful for voluntary environments.

Moreover, our system can simulate not only physical phenomenons but also social phenomenons or probabilistic process, and can display the results of the simulations by various graphical expressions such as a density graph or digraph.

3 Collaborative Learning in Virtual Environment

3.1 Virtual Environment and Learning Style

The virtual environment in this paper means a "communication environment in computer networks". Usually, a user can take only the service that he had already known the existence in the usual network. Though such information is useful, sometimes people get information that is of significant value by chance discovery. We think that positively building up and providing such an environment to increase the chance of this happening are important. The virtual environment in made by various information can be considered for the typical example. In this paper, we use VESMA system to realize the collaborative learning support system. Because of server-client architecture supported by VESMA system, our collaborative learning support system can be "distributed" in space and "synchronized or non-synchronized" in time. Generally, learning styles can be divided into the following three types : 1. *Individual learning*, 2. *group learning*, 3. ***Collaborative learning***.

(1)*Individual learning* : the problem solving whereby a learner does by himself. (2)*Group Learning* : the problem solving via task sharing. (3) *Collaborative learning* : the problem solving by use of result sharing. In other words, Each learner solves his own problem based on the information and data given to him by other learners. Thus Collaborative learning is group learning with more goal oriented communications. In the field of the education, it is considered that the latter learning style is especially effective because the quality of the answer improves on the whole by having learners with differing knowledge do an information exchange.

3.2 Collaborative Learning

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The following are the strong points of collaborative learning in a virtual environment[2] : (1)There is no restriction of time and geographical space. (2)It can lead to solving problems by doing opinion exchange with other people. (3)It can obtain objective awareness of problems. On the other hand, it has several weak points : (1)Learners get behind if they don't participate voluntarily. (2)There is the possibility that learning may progress in different directions. (3)Differing abilities of learners (members) may be a problem for the progress of their learning. We think about the method of the learner support which a weak point 3 is changed to the strong point.

Good ideas in subject preparation, group formation support, communication support, and ideas such as an interface become necessary to get over these problems. We examine the interface using intelligent agents in consideration of such characteristics in this paper.

4 Supporting Collaborative Learning

4.1 Grasp of the learner's state

It is important to grasp learner's state in the learning system. When learning in a virtual environment on the computer network, it is especially important. Because, people's communications become indirect in a virtual environment.

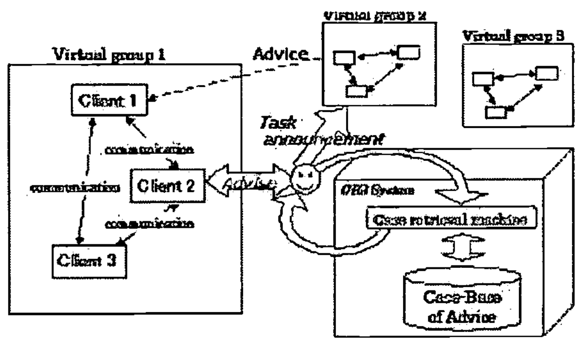

Fig. 3 Architecture of Collaborative Learning Support System

Generally, when students learn about certain topic, offering materials suitable to the learner's level of understanding is necessary. This research aims to check the learner's mental state, in broad sense, using agents to grasp it automatically. It is also important to promote collaborative learning smoothly by giving a kind of "role" to each learner in the group in consideration of the learner's personality. For example, the learner who is good at teaching others might become a leader, and give support to other learners in the group. The control that gives hints to make it refer to an exercise is necessary for cases when learners come to a deadlock in their learning.

4.2 Learner Modeling

Then, the following is necessary for the learner modeling from the viewpoint of collaborative learning,
The individual model : It has proper knowledge, the mistaken knowledge, the knowledge that it hasn't been studied; the interest or concerns, information such as a role, personal manipulation history.

$D_l = \{(T_1,U_1).....(T_n,U_n)\}$ D_l : learner model, T_i : learning topic, U_i : understanding of topic

4.3 Intelligent Agents

An agent works like a human beings, and supports teachers and learners. An agent communicates other agents or avatars, and behaves actively in various situation. Making a graphical representation of these agents, users can come in contact with an agent familiarity. In this paper, we will discuss the intelligent agents (*'learner modeling agent*', "*group agent*", "*advisor agent*", "*evaluation agent*") who support collaborative learning in virtual environment.

The *learner modeling agent* grasps the learner's degree of progress and the degree of his understanding. The *group agent* controls the information that a *learner modeling agent* has, and monitors the relationships of each learner in the group. An *advisor agent* carries out various supports directly for the learner. An *evaluation agent* judges whether or not the knowledge that a learner got by working at collaborative learning is useful. **Fig. 2** illustrates the architecture of collaborative learning in virtual environment including *advisor agent*. These agents do various support while the learner advances collaborative learning.

As different autonomous object, some characteristic mascots may be included in our Virtual University based on a feature described in 2.3.

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5 The method of some supporting in Collaborative Learning

5.1 Collaborative Learning Support

As an example of collaborative learning support, *pattern1* • •When you come to a deadlock. *pattern2* • • When you mistake the solution. *pattern. 3* • •When you can not understand what to do next.

How to solve the problem of the pattern 2 : First is support by the learner in the group(using *Contract Net*). Next is support by the learner in other group(using *Contract Net*). Finally is Support by the *CBR* system. *Contract Net* achieves the allocation of the task by the negotiation between the processing nodes. In this paper, the selection of the advisor was attempted by contract net. We think it might be easier to understand "By getting advice from the learner who is close to one's understanding degree".

5.2 CBR and Calculation of Similarity Degree

CBR(Case-Based Reasoning) is a kind of reasoning which solve the new problem by a case similar to current problem. A case is expressed as

$$D_c = \{(T_1, U_1, W_1).....(T_n, U_n, W_n)\}$$

follows.

D_c : case, T_i : learning topic, U_i : understanding of topic, W_i : importance degree of topic

The advisor agent selects a case that current condition and a case are the most similar.

$$Sim_{cl} = \sqrt{\sum_{t=1}^{n} W_t (U_{ct} - U_{lt})^2}$$

Sim :similarity degree, U_{ct} :understanding degree of topic of case base, U_{lt} : understanding degree of topic of learner model, W_t : importance degree of the topic

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6 Concluding Remarks and Future Works

We have constructed a virtual environment on a VESMA system, and examined communication processes on it. And, we have examined the function of the intelligent agents in the collaborative learning support system and the validity and support for the learning process.

In this paper, we have discussed that learners can obtain better methods for voluntary learning by the appropriate support of the intelligent agents. And various intelligent agents provide environments for the group learning which enables learners to do active collaborative learning.

And we have realized practical collaborative learning support system in which the following advantages are provided using VESMA system. The learners communicate each other and share the teaching/learning materials in the virtual environment by not only a text-based interface but also a graphical interface. A user of VESMA system can move among two or more servers which is distributed in the Internet. We can make a small creature, or can make physical experiments because of the function of VESMA which realize autonomous objects. And VESMA system has the layered structure of virtual environment, so many places can be constructed in one server corresponding to user's spatial metaphor, and the learner can easily access a place he/she wish.

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A Constructivist Virtual Physics Laboratory

Fu-Kwun Hwang
Dept. of Physics, National Taiwan Normal University
#88, Sec. 4, Ting-Chou Road, Taipei, Taiwan 116
Tel: +886-2-29346620
Fax: +886-2-29326408
E-mail:hwang@phy03.phy.ntnu.edu.tw

A virtual Physics Laboratory with 60+ physics java applets was established for student to play and enjoy learning physics (http://www.phy.ntnu.edu.tw/java/). Our java applets are ready over the net, easy-to-use and meaningful for many physics teachers, whose primary concern is teaching instead of technology. Learners do not have to sit passively watching the java animation. They are allowed to interact with the animation themselves. It requires learners to constantly make decisions about which parameters to modified and evaluate progress, thus forcing students to apply higher order thinking skills. The size of the java applets is small, usually less than 30k, which is suitable for the overcrowded Internet. Many physics teacher around the world already design worksheets incorporate with our java applets in their day-to-day instruction. Our goal is not only to help learners accomplish their physics learning faster or more effectively, but also to engage them in new ways of thinking, enjoy the funs of physics and apply their physics to everyday life. It can be operated as different kinds of modes, such as studying individually, study cooperatively and having lessons collectively etc. These attributes closely match those of modern educational theories where learning should be a self-motivated and rewarding activity.

Keywords: **Java Animation, Virtual Laboratory, Computer Assisted Learning.**

1 Introduction

Many have predicted that the Internet, particularly the World Wide Web, will transform education. As more schools adopt the internet and more teachers and students become increasingly interested in the web-based activities, the need for easy-to-use and meaningful web learning environments has increased dramatically. At the same time, education research has shown that the learning style and student-centered learning are important to meaningful learning . Learning becomes an active process of discovery and participation base on self-motivation rather than on more passive acquaintance of facts and rules [8]. Current and emerging technological advances in information and communication technology make it possible to develop interactive learning environment to support new ways of learning. The most promising technologies are based on virtual machines, meta-languages, and open Internet standards. Although the Internet lowers the barriers to authoring and distribution of educational software, its ability to deliver active content may, in the long run, be more significant. Interactive learning environments are having an increasing role in teaching and learning, and are likely to play an important role in the future [10]. In particular, those tools that encourage/enhance discovery, creativity, and thinking are very much needed.

One of the most exciting developments is the integration of interactive software into web-based courses using the Java programming language. Many physics teachers and students recognized benefits of using the WWW to enhance teaching and learning, while they were using our Virtual Physics Laboratory (VPL). We have developed more than 60 physics related java applets, which become the core of VPL. Java animations developed at our site offer many advantages for the integration in our didactic concepts: All of our java animations visualize the effects and parameters of the related physics concepts or phenomena. It provides

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user to manipulate all necessary parameters in a very intuitive and interactive way. Through modifying these parameters in java animation, students get a much better understanding of the underlying physics and mathematics aspects. Our tools are easy-to-use and meaningful for many physics teachers, whose primary concern is teaching instead of technology. The most important implication of choosing a web-based technology is the way it facilitates sharing. We have received tremendous email feedbacks from physics teachers, parents and students all over the world. Many teachers developed their own worksheets in cooperated with our java applets, and used it in their classroom. Due to the slow connection over the Internet and many requests from educators, our VPL contents were distributed as mirror sites at more than 35 educational institutions around the world.

2 The Learning Process

Traditional approaches to education promote subject-based learning, which encourage teachers to focus on covering materials and students to adopt surface learning which fail to integrate knowledge [3]. When the television was invented half century ago, many had predicted that the television would transform the education. Some people thought if the best teacher were lectured on TV, all the students would be educated under the best environment. We have learned the lesson, teaching and learning is not delivery process between teacher and students. It appears that "learning consists of the growth of additional neural connections stimulated by the passage of electrical current along nerve cells (neurons) and enhanced by chemicals (neurotransmitters) discharged into the gaps (synapses) between neighboring cells" [11,12]. People learn differently and know things differently because they take different pathways on different occasions; which related to the context, their previous experiences, and their physical and emotional state. Not all pathways are accessed in the same way. However, as a particular pathway is re-used, additional connections are built which strengthen the linkages. Some of these mental pathways become so worn that the mind seeks to use these easy routes to arrive at an understanding. In many case, learning means making new pathways, adjusting pathways or removing pathways among memories that become "known" as incorrect. Learning is a personal activity and the function of a teacher is to help student create interaction between subject under studied and student's cognition structure.

The rapid advancement of the Internet, particularly the development and prolific expansion of the WWW, enable educators to create multimedia teaching resources and interactive instructional strategies which can be delivered to any students without regard to time, place, or computer platform. However, the medium of delivery is not the sufficient condition for learning. Education research informs us that technological advances do not necessarily lead to improve learning. Nothing happens until the learning is actively engaged. For today's technology to have a long lasting impact on science education, it will need to base more on successful pedagogy than on the latest compilers, hardware, or algorithms.

Interactive engagement (abbreviated IE) teaching methods take many different formats [2]. All of them, however, force the student to play a much more active role in the learning process, increase the amount of interaction with fellow students and instructors, and emphasize conceptual understanding as well as quantitative problem-solving. Hale's study [1] compared IE methods, with traditional lecture methods at variety institutions, and showed a significant, across the-board improvement in students' conceptual understanding in IE classes. The most dramatic differences are seen in the area of conceptual understanding. The interactive capabilities of WWW-based instructional strategies can be employed to better match how we teach with how we know students learn.

3 Virtual Physics Laboratory: Enjoyable place to play and learn physics

Game playing is a self-motivated and rewarding activity. An enjoyable computer game is found to be player centered, and it must enhance discovery. Learning should be a self-motivated and rewarding activity, too. Can we make learning as motivated and rewarding activity as computer game playing? This was the initial spark for the VPL project, to develop an enjoyable interactive learning environment helping learners to make sense of physics.

Research on animation can be organized according to the purpose of the animation. In general, instructional graphics satisfy five purposes: they are cosmetic, motivation, attention getting, presentation, and practice [7]. Cosmetic and motivation are in the affective domain, while the others are in the cognitive domain.

1. Graphics used for cosmetic purposes are used to "dress up" the text. Unfortunately, learning does not take place directly as a result of cosmetic graphics. Rieber notes, "At their best, cosmetic graphics help maintain student interest. At their worst, cosmetic graphics distract student attention from other important material."
2. Graphics used for motivational purposes, appealing to the viewer's attitudes. It's important for learner to see material as exciting and relevant. Although learners may be motivated by novel graphics, they may also become saturated as they are inundated with such visuals. As a result, motivating visuals can quickly lose their instructional impact.
3. Graphics used to gain attention. Their primary difference from motivational graphics is that they are not designed to influence the attitude of the viewer but rather to focus the viewer's attention. Attention-gaining graphics may directly influence students' learning, thus it is classified according to the cognition domain of learning. A good example is our "Thin Lens Animator"[13] that shows the images of an object in front of a lens as user click and drags the object across the screen.
4. Graphics used for presentation. For instance, our "Pendulum Animation"[14] is not only present a dynamic visual, but also present data. The data is observed to change as the animation is running. Therefore, the learner can make a connection between the state of the data and the state of the animation.
5. Graphics used for practice activities. This purpose is especially suited to interactive computer simulation where learner receives feedback based on his or her input. For example: Users can type in the base frequency and modify different components of higher order frequency with mouse to create new sound wave and hear it instantly in "Fourier Synthesis"[15].

Our Java applets can be used for all the aforementioned purposes. Most of all, we focus more on students' cognition development. The created java applets aim at invite students to develop deeper, more connected understanding of physics concepts. Seeking connections in contrast to the conventional model of learner as receiving information and of instruction as providing information, in short, to promote conceptual change. According to Rieber, there are two prerequisites for animation to have positive effect on learning outcomes: (1) there must be a need for external visualization (2) learning of the described phenomenon must require an understanding of how an object's properties change with time or position. Rieberb recommends, "Animation should be incorporated only when its attributes are congruent to the learning task". That is, the animation may not be an advantage over a static image in all case. We have designed our java applets according to the recommendation. Many physics concepts especially those involve spatial and time variance, such as stationary wave, Doppler effect[16], and so on, are difficult to express clearly in words or in pictures on the blackboard. By means of our animated java applets, drawing or demonstrations, teacher can cut down the lecture time in class and enable students to understand physics concepts more effectively.

Examples 1:Traffic light system (html page 6k, java class files 27k)[17]

Situation: "Would you like to engineer the traffic light system for a one-way street that consists of several lanes along which rush-hour traffic flows? How would you time the onset of green lights at the various intersections? How to apply what you have learned in kinematics to promote the traffic flow? This java applet let you play with it and find out your answer." All the relevant information is provided for students to find out the answer. This is an authentic situation; the underline principle was used in many cities to control the one-way traffic lights. Each moving square in Figure 1 represents a car, its color indicates whether the car is accelerating, moving with constant velocity, or stopped. The height of each blue circle gives information about the velocity of the corresponding vehicle. User can adjust the timing between green light, yellow light and red light, change time delay between successive intersections, ... etc. It is a kinematics problem for high school students related to topics in constant motion and motion under constant acceleration. Students can work in-group, discuss with each other, propose solutions, explain the reasons of their predictions, use physics concepts to analyze and synthesis the answer, and run the animation to compare and find out the answer. Many students find it is a fun game to play and they gain deeper understanding of related physics concepts at the same time.

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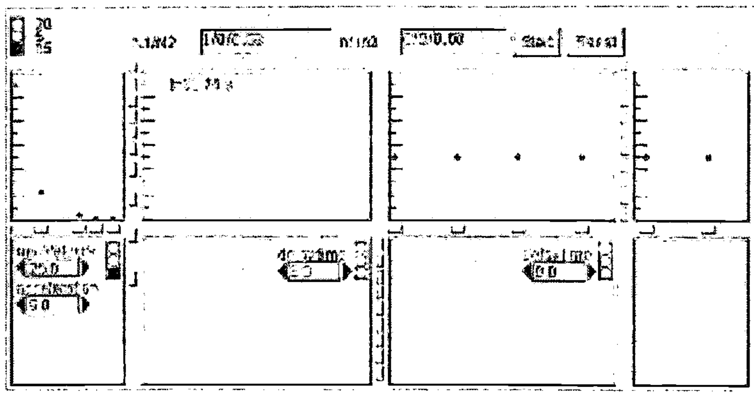

Figure 1: Screen shot of Traffic Light System java simulation

Example 2: Measure your Reaction time (html page 6k, java class files 20k)[18]

Situation: "You are driving on the high way and listening to the music you like most. Suddenly, you see the brake light of the car in front of you just turned on. You will try to hit the brake and slow down your car. But, there is a small time delay before you really do that--- your reaction time. During that period of time, your car is still moving at the same HIGH speed! If you do not want something VERY BAD happened, what is the minimum distance between your car and the one just before yours?" This is a very dangerous situation in real life. However, students can try out such experiments with our java animation safely.

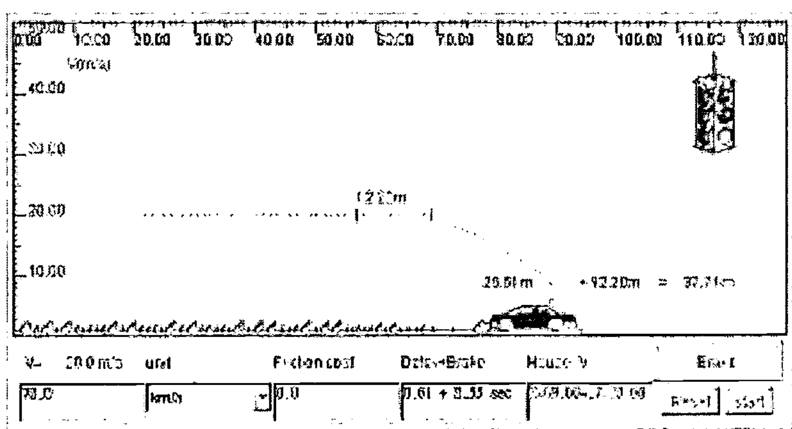

Figure 2: Screen shot of Reaction Time Measurement java animation.

As shown in Figure 2, when the user clicks the button to start the animation, the car will move from left to right at preset constant velocity. The streetlight will turn from green to yellow, and then turn to red light at random selected time. User needs to click the "Brake" button when the red light is on. Those small dots were generated at run time; its height shows velocity of the car at the same horizontal position. Users can move the mouse within the area to find out corresponding value for each dot. Figure 2 indicates the vehicle is moving at 20m/s (72km/hr), arrives at the first red bar when the red light turn to red, and user click the "Brake" button after the car runs 12.2 meter more (the second red bar position). So the reaction time for the user is measured to be 0.61s for this case. It also shows car running at 20m/s need 25.51 m (or 2.55s) to fully stop after driver hit the brake. (Assuming the friction coefficient between the road and the tire of the vehicle is 0.8, which is a typical value for auto tires on dry concrete.) Users can measure their reaction time with this simple java applet, and find out the safe distance to keep when they are driving on the high way. This java applet also reminds users that the braking distance for the vehicle is proportional to the square of the velocity. When you change speed of your car from 80km/hr to 100km/hr, the braking distance increased by a factor of $(100/80)^2 = (1.25)^2 = 1.56$ (velocity increased by a factor of 1.25). Such requirement is a law governs by nature. May be you can miss the speed ticket if the police is not there; however, car accident will happen if not enough distance were reserved for the corresponding speed. This is a very important lesson need to be

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learned; it can save people's life.

Most of the functions provided by our java applets are operated with mouse click and drag, ease to use and intuitive. Sound, colors and good animated drawings can attract learners' attention and sharpen their ability of thinking. Many more examples can be found at our VPL. Interaction between the student and the learning materials is essential. For different learning tasks different interactivities are appropriate. The design of java applets focused on promoting students' integrated understanding of physics concepts through the use of carefully designed curriculum. We want to generate sequences of stimuli that can be used either to activate a person's existing mental models or initiate the development of new ones. To enable student to connect new ideas to their existing knowledge, making bridge to connect their own piece of information. Our approach is remarkably different from typical novice strategies where students attempt to mathematically analyze a problem before qualitatively describing it (an approach often called "plug-and-chug" and characterized by the lack of conceptual though during the problem-solving process [9]). Requiring student to consider problems qualitatively has been shown to have a positive influence on students' problem solving skills and conceptual understanding [5,6].

In physics, information about a physics system were represented in many different ways: using words, equations, graphs, diagrams, table of numbers, contour maps, vector plots, and so on. Many students have considerable difficulty, not only with creating these representations but also in seeing how they express information about the system and how they are related to each other. Our VPL can help student conquer their learning difficulty. With so many feedbacks from teachers, parents and students all over the world, we found

1. Applets in VPL can help students make sense of translation among representation: Showing animations of a dynamic system and move the relevant information to a coordinated graph, diagram, or plot can, when used in conjunction with an appropriate lesson, significantly help students develop skills in using different representations to help them make sense of the physics. For examples: "Superposition principle of wave", "Simple harmonic motion" and "Transverse Wave and Longitudinal Wave" java applets.
2. Applets in VPL can help students understand equations and physical relations among measurements. Many students treat equations as if they were only a way to calculate a variable or determine a number as a solution. Physical equations represent relationships between various observations and measurements. We know how the nature operates from those relations. For examples: " Spring Force and Simple Harmonic Motion", "Thin Lens" and "Double Slit (interference) " java applets.
3. Applets in VPL can help students build mental model of physical systems: In some cases, students don't have the experience or imagination to put together what they are reading in the texts and hearing from the lectures into a coherent, sensible picture. They memorize bits and pieces, but because these pieces are not linked into consistent, self-supporting structure, they forget or confuse the parts. Visions of interacting objects having qualities and measurable properties. Producing visualizations that display these characteristics can help students create these mental models. For examples: "The location of an supersonic airplane", "Moving point source (Doppler effect/Shock wave)" and "Propagation of electromagnetic wave".
4. Applets in VPL can give students engaging, hand-on, active learning experiences. Students learn much more effectively when they have control on their own learning. Having animations that students can use to explore phenomenon on their own, can produce more effective learning experiences. For examples: "Reaction time and car accident ", "The electronic multimeter" and " Projectile/Satellite Orbits" java applets.
5. Applets in VPL can serve as a sketchpad on which students can explain and describe their understanding to each other. Educational research shows it is valuable to have students explain what they are thinking, both to themselves and to each other. Two or three students working together to answer questions with a simulation can produce a powerful learning environment. For examples: "Physics of rainbow", "Billiards and Physics" and "Mixing colored light beams/paint pigments" java applets.

4 Future work

When learners are novices in the content area, they may not know how to attend to relevant cues or details provided by animations. Teacher can provide hints or demonstrations in the classroom and find out how the learner operated with the java animation. However, VPL is designed for web access, which allows students' direct access without teacher's guidance. All of our java applets are client-based simulations. We see the needs to establish communication between client and server. We will extend their function to support client-

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server communication: to control and synchronize animation running on several machines, to exchange data between distributed applets. Besides, it can be used to monitor how the remote user operated with our java applets, identify when they encounter difficulty for research purpose and provide assistance at the same time. Therefore, our java applets can be used as stand-alone learning tools or as shared animations to support cooperate learning over the net.

5 Conclusions

Many web sites are aimed at providing information while we focus on interactive animations to assist student construct his/her own physics concepts. The VPL offers possibilities to concentrate on student-centered approach for learning. Learners do not have to sit passively watching the java animation. They are allowed to interact with the animation themselves. It requires learners to constantly make decisions about which parameters to modified and evaluate progress, thus forcing students to apply higher order thinking skills. Our java applets are ready over the net, easy-to-use and meaningful for many physics teachers, whose primary concern is teaching instead of technology. The size of the java applets is small, usually less than 30k, which is suitable for the overcrowded Internet. Many physics teacher already design worksheets incorporate with our java applets in their day-to-day instruction. We welcome lectures to translate our web pages into their own languages and share with us. All the labels and texts used in the java applets can be easily changed to local characters with any web page editor. This provides many users at different countries to use our java applets for their teaching and learning. Our VPL can be used as a teaching tool during the lecture or as assignments for the students to play and enjoy learning physics. It can be used in different ways, such as studying individually, study cooperatively and having lessons collectively etc. Our goal is not only to help learners accomplish their physics learning faster or more effectively, but also to engage them in new ways of thinking, enjoy the funs of physics and apply physics to their everyday life. These attributes closely match those of modern educational theories where learning should be a self-motivated and rewarding activity.

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A Distributed Backbone System for Community-Based Collaborative Virtual Universities

Qun Jin *, Jingde Cheng **, Hiroaki Ogata * and Yoneo Yano *****
** School of Computer Science and Engineering, University of Aizu, Aizu-Wakamatsu City, 965-8580 Japan E-mail: jinqun@u-aizu.ac.jp*
*** Department of Information and Computer Sciences, Saitama University, Urawa, 338-8570 Japan E-mail: cheng@ics.saitama-u.ac.jp*
**** Department of Information Science and Intelligent Systems, Tokushima University, Tokushima, 770-8506 Japan E-mail: {ogata, yano}@is.tokushima-u.ac.jp*

In this paper, we propose a new framework for community-based collaborative virtual universities, which not only support the delivery of knowledge from an expert to a group of learners, but also facilitate the exchange and distribution of knowledge between large and diverse groups of people. We discuss designing and prototyping of a distributed backbone system for community-based collaborative virtual universities, in which computation is effectively used to provide organized proper support for communication, interaction and collaboration between human users and between a human user and the system as well.

Keywords: **Distance learning, virtual university, virtual community, MOO, software agent.**

1 Introduction

Information and network technologies have been changing how people work, live and learn. The so-called Internet revolution has brought great impact on the global society, and is greatly changing the educational systems. In recent years, distance education/learning and virtual universities have been attracting more and more attentions, and play an important role in the educational system revolution for the new coming century.

Virtual universities cover a very broad field. Many research works have been conducted in the domain [1, 2]. However, experiments and experiences have demonstrated that electronic communication in the networked virtual environment has some different characteristics from face-to-face communication in the real world [3]. Many studies have also shown that learning in the networked virtual environments involves approaches that are not typical of general classrooms [4, 5]. It is necessary for a virtual university to have general functions, utilities and resources of a physical real world university available on the networks. However, it is not enough and efficient only trying to move a physical university to the virtual world without considering on the fact that there are great differences between physical and virtual universities.

In this study, we propose a new framework for community-based collaborative virtual universities, which not only support the delivery of knowledge from an expert to a group of learners, but also facilitate the exchange and distribution of knowledge between large and diverse groups of people. We design and develop a distributed backbone system for community-based collaborative virtual universities, in which computation is effectively used to provide organized proper support for communication, interaction and collaboration between human users and between a human user and the system (a networked computer and/or a software agent) as well.

2 Framework for Community-Based Collaborative Virtual Universities

The Internet provides a universal, free, and equal electronic communication environment for people of all ages with different education backgrounds, ability levels, and personal inclinations. It makes knowledge delivery, sharing and building possible among large and diverse groups of people across the networks.

The central purpose of community-based collaborative virtual universities is to provide a learning environment that widely opens to large and diverse group of people who have the will to learn and to share their knowledge with others across the networks. They are a networked virtual workspace with the time-independent and place-independent access, in which computation is effectively utilized to actively and properly support human-human communication, interaction and collaboration in addition to human-computer communication, interaction and collaboration, towards effectively assisting and enhancing learning activities in the virtual environments [6].

Community-based collaborative virtual universities are participants-driven. That is, participants or learners share a common interest in a topic or area, share a way of knowing and a set of practices [7]. Knowledge is not just delivered from teachers or experts, but also constructed by participants' team works and/or discussions. Community-based collaborative virtual universities support different ways for novices and experts to work in the same environment to accomplish similar goals. They may be large, the task general, and the communication open. Alternatively, they can be small, the task specific, and the communication close.

3 Design and Implementation of the Distributed Backbone System

3.1 Overview

The backbone system for flexibly supporting community learning has been designed so that a learner can navigate through it, select relevant information, respond to questions using computer input devices such as a keyboard, mouse, or voice command system, solve problems, complete challenging tasks, create knowledge representations, collaborate with others, or otherwise engage in meaningful learning activities.

Figure 1 shows an overview of the distributed backbone system for community-based collaborative virtual universities, which have been implemented in MOO (Multi user dimension Object-Oriented), well known as a text-based social virtual reality [8]. Human users and software agents co-exist and interact in the MOO based virtual community. Social interaction between users is actively mediated and facilitated by cooperative agents who support their learning activities in the virtual environments as well.

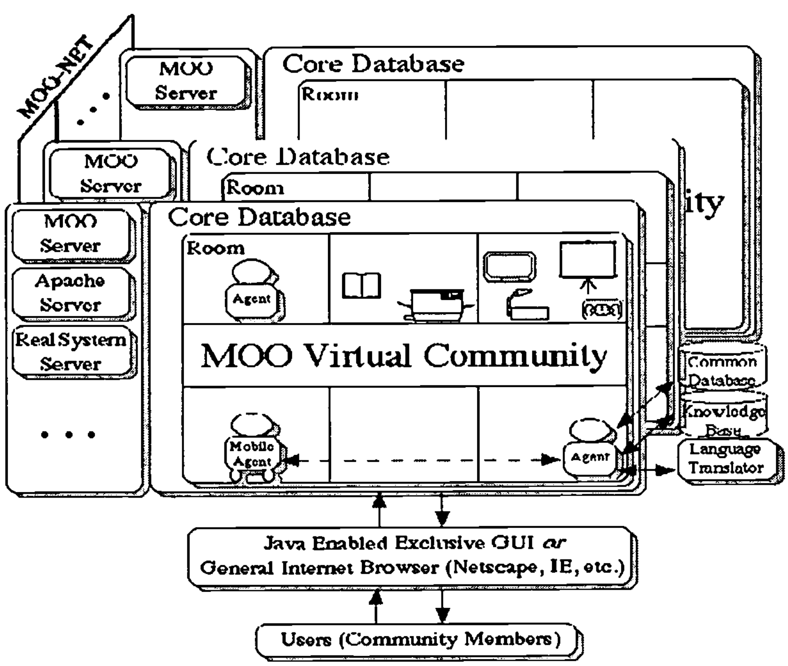

Figure 1 Overview of the MOO-Networked Backbone

3.1.1 Web and Multimedia Integration

To fully utilize multimedia such as graphic images, sounds, and/or movies, we have integrated the MOO Server with the web server (e.g., Apache Server) and other servers providing multimedia services (e.g., RealSystem Server). Since the seamless integration of the MOO Server with the web server, technically, it is possible to integrate MOO with any types of server services and incorporate any type of multimedia such as MPEG1, MPEG2, and/or MP3 data in the MOO virtual environment.

3.1.2 Graphical User Interface

Java enabled exclusive graphical user interface specially designed for accessing MOO virtual environments has been developed. Consequently, MOO commands and verbs could be transferred to a hyper link. For example, users can go in or out of a room by simply clicking a corresponding hyper link that represents the entrance or exit; they may read a note by clicking the hyper link representing the note. Since it is constructed with Java language, it could be run with a general Internet Browser (e.g., Netscape, Internet Explorer).

3.1.3 Software Agent Support

To further provide flexible and proper support for communication, interaction and collaboration in the networked virtual environments, a multi agent paradigm has been adopted in this study. We have proposed a kind of software agents that adapt well to users' behavior and incorporated them both within the MOO environment and on the interface which we call interface agents, and integrate one interface agent for each user that bridges the virtual environment and the user to aid his/her manipulations and various activities.

Interface agents provide different ways of supports. They may provide suggestions, answer questions to a user. They can search something from an outside database or knowledge base for their owners by ``*wireless*" communication with the DB/KB agent to transfer their owners' request and obtain the search results. Interface agents may accompany a user to move around the virtual environment if the user requests so. They can also provide actively supports to a user once a problem occurs.

In addition to interface agents, there are also various types of software agents inside or outside the virtual community, which are called task agents. Task agents provide specific functions or resources available in the local environment or outside over the Internet to interface agents directly or indirectly. In the latter case, they are mediated by a so-called mediator agent.

3.1.4 Multilingual Environment with Language Translator Agents

Due to the diversity of the users in the community-based collaborative virtual universities, it has to encompass the needs of people of all ages, races, and nationalities with different education backgrounds, and ability levels. Consequently, this causes a language problem in knowledge representation and communication.

As described in the previous sections, integration of MOO environment with the web and multimedia service servers make it possible to play sounds and movies in any language, and display information and knowledge on the Java enabled graphical user interface or a general Internet browser in a language that the client program and browsers may support. However, the language has to be selected and specified by the users themselves. Moreover, it is impossible to conduct real time communication in different languages.

In this study, we have created a new kind of task agents (translator agent) that serves for each users and automatically select one suitable language for the user to communicate with others and browse the information and knowledge in the virtual environment according to the information given in a pre-defined property. The translator agent can also translate for the users from a non-native language to their tongue, even though they understand the non-native language. The agent may also display the original languages that other users speak in addition to the translated language.

3.1.5 Distributed Virtual Environments with MOO-net

To effectively provide general university functions, utilities and resources over the networks, we have designed the backbone system as a distributed one based on the MOO-net mechanism, which is a low-bandwidth information network for the MOO family and operates using a packet-switched model [9]. As a result, distributed virtual lecture could be delivered across the MOO-networked virtual environments using a

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special virtual lecture hall. Real time communication could be conducted between users in different MOO virtual environments. Further, agents may communicate with other agents in different virtual environments, and even search objects from there for users.

3.2 Prototyping Implementation of the Distributed Backbone System

The prototype system has been implemented in the three test-beds isMOO (available at URL telnet://n132.is.tokushima-u.ac.jp:6666 or http://n132.is.tokushima-u.ac.jp:6868), izMOO (available at URL telnet://pross50.u-aizu.ac.jp:8888 or http://pross50.u-aizu.ac.jp:7000) and vu21MOO (available at URL telnet://vu21.u-aizu.ac.jp:6666 or http://vu21.u-aizu.ac.jp:6868) which are running under the LambdaMOO Server with the Japanese patch and the JHCore and enCore Databases with MOO-net (http://www.cs.cf.ac.uk/User/Andrew.Wilson/MOO-net/), the RealSystem Server (http://www.realnetworks.com/ products/servers/index.html), and the Apache Web Server (http://www.apache.org/httpd.html).

The LambdaMOO embedded object-oriented script language has been used to construct programs for software agents within the MOO virtual environment, although it is possible and might be more *powerful* to create task agents outside the MOO virtual environment using a standard programming language. Our prototype translator agents support three languages: English, Chinese and Japanese.

4 Conclusion

This study aims at proposing and building an innovative educational system for the coming new century. In this paper, we have proposed community solution as an alternative for virtual universities, and described a new conceptual framework for community-based collaborative virtual universities. We have further introduced design and prototype implementation of the distributed backbone system for community-based collaborative virtual universities.

For future direction, we plan to improve the functions of proper communication support based on studies of natural human communication processes, and design and develop an educational information resource base with high quality multimedia. We will further develop mechanisms that facilitate mutual understanding beyond differences in place, time, language and culture, and make the virtual environments flexibly responsive to users' behavior.

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A Flexible Transaction Model for Virtual School Environments

Woochun Jun*, Sukki Hong**
**Dept. of Computer Education*
Seoul National University of Education
Seoul, Korea
E-mail: wocjun@ns.seoul-e.ac.kr
***Dept. of Business Administration*
Konkuk University
Chungju, Korea
E-mail: skhong01@kku.edu

Recent advances in Internet technologies have led to the advent of virtual schools. However, existing technologies have many limitations when applied to virtual school implementation. Especially, existing transaction models are not suitable for supporting virtual schools. In this paper, we present a new transaction model in order to support virtual school environments. First, we introduce the general characteristics of the virtual school environments. Then, we discuss transaction model requirements for virtual schools. Based on those requirements, we propose a new transaction model. We also show a locking-based concurrency control scheme for supporting collaboration works among students. Finally, we give conclusions and future research issues.

Keywords: **Collaborative Learning, Virtual School**

1 Introduction

Recently interests in virtual schools have been increasing due to advances in Internet technologies. The virtual school, which is based on distance learning, can overcome time and space limitations in the traditional schools. But, in order to complement lack of face-to-face communication in virtual schools, multimedia-based education is becoming popular. This multimedia-based education emphasizes the students' self-control. That is, multimedia- based education encourages interactions between teachers and students and also interactions among students. In the meanwhile, object-oriented databases become popular for supporting multimedia resources.

In the literature, many transaction models have been proposed for object-oriented database environments [5,7,8]. But, those transaction models have not reflected requirements in virtual schools. In this work, we propose a new transaction model that supports virtual school environments. The proposed model considers all those requirements.

This paper is organized as follows. In section 2, we discuss the transaction requirements in virtual school environments. Based on the discussion, we propose a new transaction model in Section 3. In Section 4, we present a locking-based concurrency control technique based on our model. Finally, we give conclusions and future research issues.

2 Transaction Requirements in Virtual School Environments

In this section we discuss transaction requirements in virtual school environments.

First of all, all transactions should maintain the correctness of database. One of the characteristics of database systems is manipulation of shared data. In this case, concurrency control technique is required to synchronize accesses to the database so that the consistency of the database should be maintained. Concurrency control technique requires an application-dependent correctness criterion to maintain database consistency while transactions are running concurrently. Serializability is a widely used correctness criterion [1,6]. But, serializability is too harsh for most applications so that we need user-defined correctness criteria, which is less restrictive than serializability.

Second, the length of transactions must be flexible. Usually, transaction length in virtual school environment is long since transactions are navigating on various multimedia information in database systems [2]. For long transaction case, the following problems might occur. That is, if locking-based concurrency control is adopted, long transaction blocks other transactions to run concurrently due to conflicting access. This will, in turn, degrade overall performance. Also, if a long transaction is aborted during its execution, it may waste execution time and resources it used.

Third, in virtual school environments, students' behavior is unpredictable. That is, since they are working in on-line way, it is hard to predict what kinds of actions they might take. Thus, they must be given some kind of self-controls.

Fourth, the transaction model reflects interactivity. Especially, it must support collaborative works between students and teacher or among students. Those collaborative works require common data to be shared among users in order to achieve common goal. In some cases, unlike traditional transaction model, uncommitted result by one student may be open to other students.

Finally, transaction model may need to support parallelism in order to reduce overall transaction response time. Especially, the parallelism can be used in object-oriented databases as follows. In object-oriented database, objects are accessed by means of methods. A method is nothing but a procedure to read or update attributes in objects. Two methods can run concurrently if they access different attributes in an object. Thus, transaction response time can be reduced by adopting parallelism.

3 The Proposed Transaction Model

Our transaction model reflects all requirements of transaction in virtual school environments as discussed in Section 2.

Our model is based on both Split/Join transaction model [4,9] and nested transaction model [7]. But, none of them support all those requirements of transactions in virtual school environments. Our model is to combine these two models. Our model also extends the previous model [3] so that we achieve higher parallelism as below.

The Split/Join transaction is summarized as follows. The Split/Join transaction is to restructure in-progress transaction dynamically so that it supports efficient resource management as follows. The Split transaction can be divided into two serializable transactions during its execution. In this case, two divided transactions can proceed independently with their own resources. Thus, the Split transaction model provides flexibility in resource management so that it can overcome the disadvantage of long transaction. On the other hand, the Join transaction can merge two on-going serializable transactions into one transaction. In this case, the transaction model is used to combine collaborating works into one in virtual school environments.

The nested transaction model is summarized as follows. A nested transaction consists of concurrently executable top-level transactions. In turn, a top-level transaction consists of one or more steps. Each step is either atomic operation or subtransaction. This subtransaction can run concurrently with top-level transactions or other subtransactions. In the meanwhile, a subtransaction can invoke another subtransaction. Thus, unlike flat transaction model, nested transaction model can exploit internal parallelism.

The basic structure of the proposed transaction model is shown in Fig. 1.

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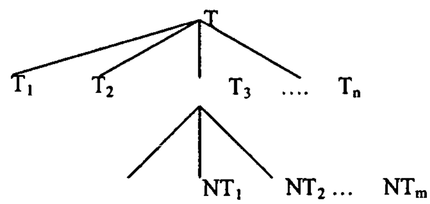

Fig. 1. The transaction model

T represents global transaction, which can be merged or split in various form during its execution. Also, depending on its nature, it can be committed without any restructuring. T_1, T_2, ,,,,T_n represent subtransaction or merged or split transaction. Also, NT_1, NT_2,,,NT_n represent subtransactions started by a nested transaction. In our model, we adopt open nested transaction [8]. In open nested environment, intermediate results of a subtransaction can be seen by other subtransaction as well as top-level transactions. This will increase parallelism further.

4 The Proposed Concurrency Control Technique

In this Section, we present a concurrency control technique based on our model. The proposed model is based on locking-based scheme. Our aim is to let two conflicting transactions go to negotiation stage if the lock requesting transaction requests a conflicting lock on a data item with a lock held by other transaction. In that case, the lock holding transaction and the lock requesting transaction can negotiate for conflicting lock types. If negotiation is successful by those two transactions, the lock requesting transaction can get a lock successfully and access the data. Otherwise, the lock request is blocked until the lock holding transaction release its locks. By doing so, the parallelism can be maximized among collaborating users. Assume that a transaction requests lock (L_R) on a data item already locked by other transaction with lock type (L_H), the following algorithm can be applied.

```
If L_R and L_H are compatible then grant L_R
        Else negotiate between lock requester and lock holder;
                If negotiation is successful then grant the lock
                        Else block the lock request;
```

5 Conclusions and Future Works

In this paper, we first introduce the general characteristics for virtual schools. Then, we present all possible requirements for transactions in virtual school environments. Those requirements are user-defined correctness, flexible transaction length, the unpredictability, interactivity and internal parallelism. Based on those requirements, we propose a transaction model and a locking based concurrency control technique.

The immediate research issue is to apply real-time concept in transaction management. In that case, each transaction must have real-time deadline. Since all transactions are on-line based in virtual school environments, the transaction response time is very critical. Thus, we will develop the real-time priority assignment scheme and real-time transaction processing scheme for virtual school environments.

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A Virtual Classroom for Algorithms with Algorithmic Animation Support[1]

Shyong Jian Shyu*, Yin Te Tsai and R. C. T. Lee*****
**Department of Information Management*
Ming Chuan University
Gwei Shan, Taiwan
Email: sjshyu@mcu.edu.tw
***Department of Computer Science and Information Management*
Providence University
Shalu, Taiwan
Email: yttsai@pu.edu.tw
****Department of Computer Science and Information Engineering*
National Chi Nan University
Puli, Taiwan
Email: rctlee@ncnu.edu.tw

A virtual classroom on algorithms with algorithmic animation and reference database supports is presented. The cognition of algorithms might need a process of individual thinking, iterative testing and experience sharing. Our virtual classroom offers learning aids on these respects via the web. The hypermedia courseware is designed to ease the navigation. A maintenance program is devised to automatically update the hyperlinks whenever the courseware is updated. Interactive algorithm animations are applied as knowledge construction assistance. It is expected that with visualization aids learners could demonstrate their comprehension of abstract algorithms. A reference database on algorithms is built up for both educational and research purposes. Studying communications such as self-testing, bulletin board, related web links, ..., etc., are also provided.

Keywords: **Multimedia and Hypermedia in Education (15), Virtual Classroom(19), Web-Based Learning(21), Algorithm Animations**

1 Introduction

The technologies of multimedia and networking on personal computers lead the research of computer-assisted learning into a new era in the last decade. Researches on the design issues of the hypermedia courseware recently please refer [17, 3, 4, 19]. Many evaluation studies also reveal positive results on learning via hypermedia courseware [7, 10, 12, 18]. With the popularity and maturity of hypermedia and web technologies, distant learning with a synchronous style via the web attracts many researchers' attention in both of the theoretical and practical points of view. The characteristics of such a web-based virtual classroom encourage the students to actively participate the construction of knowledge with their own pace and without the limitations of time and space. It is our aim in this paper to propose our design and implementation of a virtual classroom for studying algorithms with supports of interactive animations and a research paper database.

Material about algorithms is a core component for undergraduate degrees in computing. A major problem in teaching algorithms is the difficulty of capturing the dynamic movement of data and complicated data structures in static materials such as books and lecture notes [16]. Because different students learn at

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different rates, whatever pace the lecturer chooses will be wrong for some students. A virtual algorithmic classroom would be very crucial to assist students constructing their understanding with their own pace. Further, since the abstraction of algorithms might be challenging to learn and understand, it is hoped with graphical depictions the students' comprehension could be more effective and concrete. Thus we develop animations interactively by Java in our virtual classroom.

An algorithm animation is a dynamic graphical depiction of the data and operations of an algorithm. The animation purpose is to illustrate how the algorithm functions to someone seeking to learn the algorithm [15]. Researches concerning with the studies of algorithm animation or software visualization can be found on [9, 5, 13, 15, 14, 11]. A number of practical algorithm animation systems have been built over the last ten years. Some well-known systems include
BALSA [1], Tango [13], Zeus [2], AACE [6], Zeus (http://www.research.digital.com/SRC/home.htm0),
PAVANE and Opsis (http://swarm.cs.wustl.edu/pavane.html),
ZADA (http://ls4-www.informatik.uni-dortmund.de/RVS/zada.html), ...etc.
These systems typically have been used to create animations to accompany a lecture in an electronic classroom, or to prepare animations for students to observe and interact with outside the classroom. The updated technologies of multimedia tools and web programming and a complete hypermedia courseware helping students' comprehension make our algorithmic animations differ from theirs.

Besides the animations, in order to ease the tracing of the newest research results or referencing the related papers on algorithms, we built up a paper reference database to store research papers of algorithms, which can be queried and appended for educational or research purposes at the remote sites. We also provide some studying communication aids in a asynchronous mode such as self-testing, bulletin board, related web links, ..., etc., to improve the social communication among students in this virtual classroom.

The rest of this paper is organized as follows. The content of our algorithmic virtual classroom and the implementation result of our hypertextbook are presented in Section 2. The implemention of algorithm animations is illustrated in Section 3. The facility of the paper reference database is discussed in Section 4. Section 5 gives concluding remarks and future studying.

2 The Content of Our Algorithmic Virtual Classroom

There are four main themes in our algorithmic virtual classroom: (1) The Fundamentals of Algorithms, (2) Algorithmic Strategies, (3) Algorithmic Reference Database and (4) Studying Communications. Our design focuses on undergraduate students in science or management departments, while the database might have benefits for various kinds of users. The material is mainly based upon [8].

We re-organized the course material on algorithms as the hypermedia courseware (or hypertextbook) which helps the learners' actively exploring the knowledge. Each keyword (term or concept) on the web-courseware is linked onto its explanation page where the meaning is explained and all the links to the other occurrences in our courseware are also listed. A query facility for these keywords also provided. Consider that the course materials might be updated and the linkage relationships among keywords and their positions of occurrences on the web pages might also be changed. We developed a courseware maintenance program in C to automatically re-construct the linkage relation of all hyperlinks into its newest version whenever the courseware is updated. Figure 1 shows our hypertextbook on web. As the left frame shown in Figure 1, a tree-view browser is applied for learners to locate where he is in the courseware space. Figure 2 is the query result page of the keyword "insertion sort" which can also be reached by clicking "insertion sort" on the web content in Figure 1.

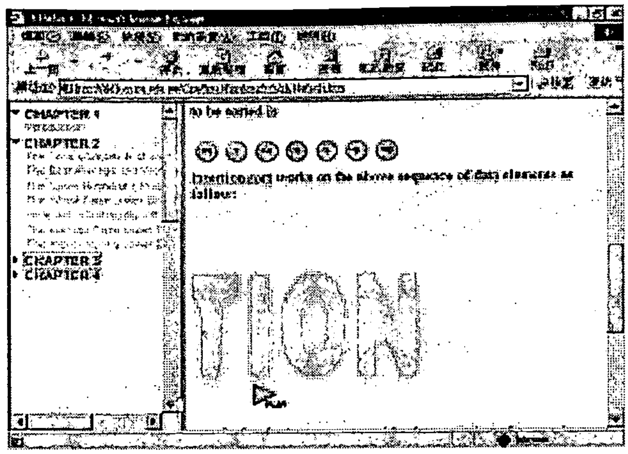


Figure 1 The web page format of our hypertextbook

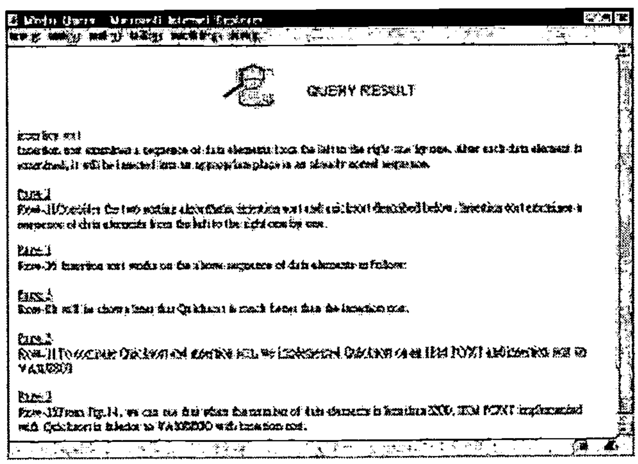


Figure 2 The query result of the keyword "insertion sort"

The content of the four main themes is described more in detail in the following sub-sections.

2.1 The Fundamentals of Algorithms

The content in this subject includes:

(a) Celebrity Hall: The contribution of some well-known computer scientists for algorithmic study such as D. E. Knuth, R. E. Tarjan, R. M. Karp, S. A. Cook, ... etc, are introduced here.

(b)The Introduction of Complexity: The concept of complexity such as order, upper bound, lower bound, ... etc, are explained.

(c)The analysis of computer algorithms: The analytic models of computer algorithms are explained. Proper examples are presented also.

All of the above materials are prepared as a web hypertextbook to ease the navigation.

2.2 Algorithmic Strategies

In current stage, three strategies are ready in our web classroom: greedy, divide-and-conquer and tree searching strategies. We not only construct the hypermedia courseware but also apply interactive animations as our learning assistants. Three interactively animated examples, i.e., solving the stamp problem, the minimum spanning tree via Kruskal's and Prim's algorithms respectively, are prepared for exploring the spirit of the Greedy method, while three, i.e., finding the maximum, quick-sort and merge-sort, interactive animations are for Divide-and-Conquer and three, i.e., breadth-first-search, depth-first-search and hill-climbing, for tree searching. The implementation result is illustrated in Section 3.

2.3 Algorithmic Reference Database

It is most critical in almost every research areas, including of course the research of algorithms, to maintain a mostly updated reference database. We construct a web-based database via CGI technology to maintain those important references related to algorithms. Section 4 shows the implementation result in detail.

2.4 Study Communications

To increase the content of our courseware, we collect links of some important related web sites in our external-resource pages which enlarge the learners' view on the studying of algorithms. Meanwhile, to help students to self-evaluate the learning effect, self-tests are provided for learners to answer yes-no question sheets on the web. The system will score the result and give explanations automatically.

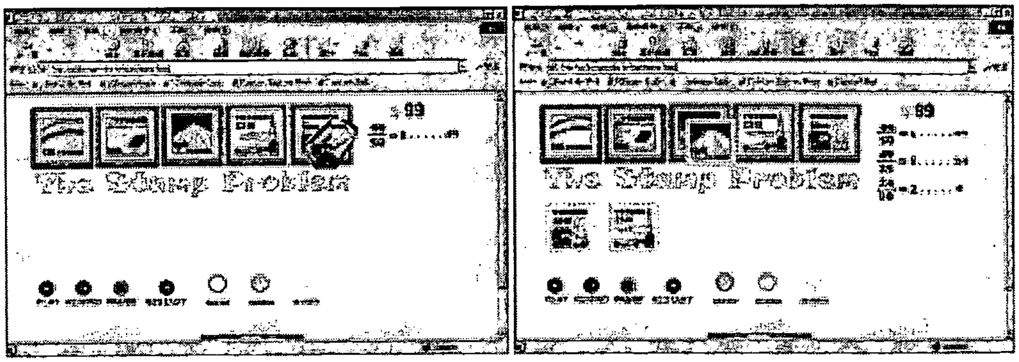
In order to improve the social communications for students in this asynchronous learning environment, we provide some interactive facilities:

(a)Bulletin board: This is an area for learners and teachers to post their idea, suggestions, questions, ...etc., on the web pages remotely. They could share the learning experience or learn from peers without the limitation of time or space.
(b)Paper up-loading: A web interface is provided for users to up-load their finding of new research papers on algorithms.

3 Interactive Algorithm Animations

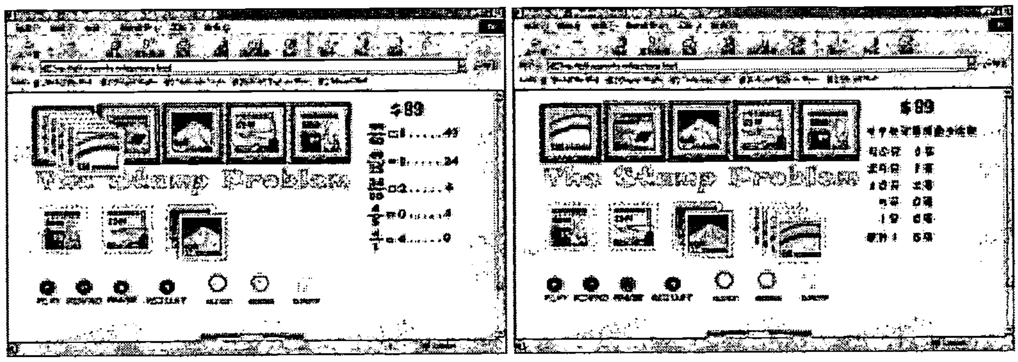
Algorithm animations might be an effective tool for understanding the behavior and abstraction of algorithms. However, most approaches mentioned in Section 2 have focused on much sophisticated graphical depictions and not on the process of how learners construct their comprehensions via animations. As a way, two categories, static animation and dynamic animation, are considered in our virtual classroom. The former cannot be changed once built, while the latter might be changed according to some predefined parameters. We call the dynamic animation as interactive animation if the learners can assign values to those parameters in an on-line manner. The learners can choose either one to observe the actual data moving and to demonstrate their abstract concept. A control panel is provided for learners to control the running speed.

The static animations by Director offer multimedia presentations. Figure 3 illustrates an animated example of solving the stamp problem, which is to explain the greedy method. The interactive animations by Java allow the learners to change the animated results by assigning input variables with different values. Through observing the various running situations in terms to the given variables, learners can realize how those algorithmic steps are actually executed. It is expected that the conceptual cognition of these abstract strategies can be enhanced via the visualized running examples and the learners' comprehension could be more concrete. Figure 4 shows an example of merge-sort where the number of input instance can be assigned in an on-line manner.



(a) the stamp with largest value is chosed

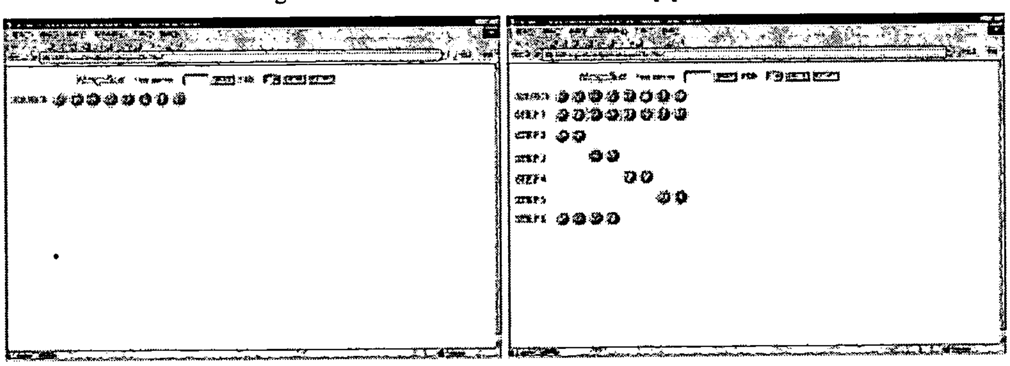
(b) running with greedy



(c) running with greedy (cont.)

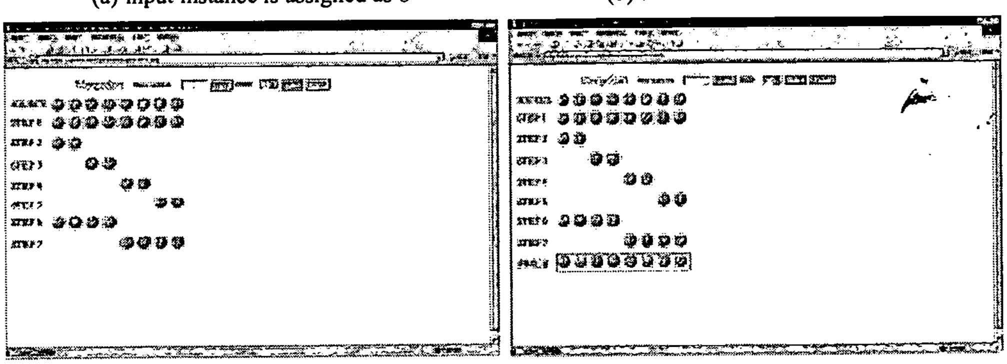
(d) the final result

Figure 3 The static animation for the stamp problem



(a) input instance is assigned as 8

(b) the left half balls are sorted



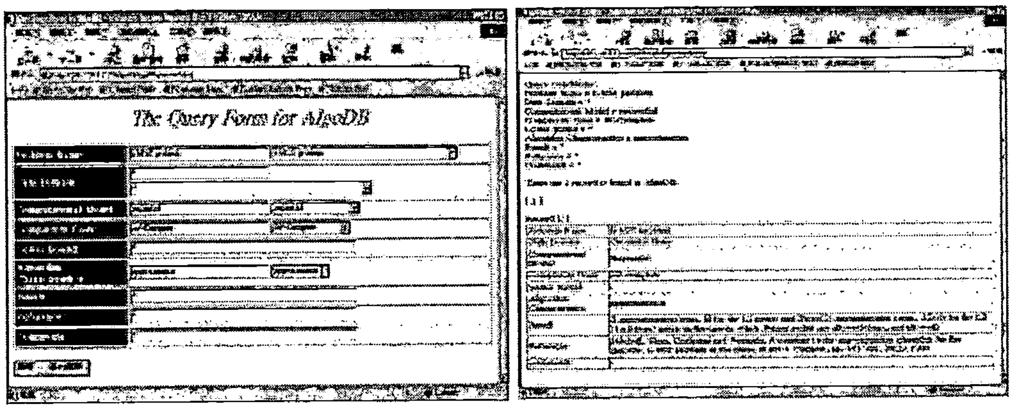
(c) the right half balls are sorted

(d) the final result

Figure 4 The interactive animation for the merge-sort problem

4 Reference Database Support

To meet general researchers' requirements, it is designed to supporting query by using various fields such as: problem name, data domain, computational model, complexity class, lower bound, algorithm characteristics, result, reference and comments. It also supports the up-load functionality for interested researchers to up-load their new findings all over the world. This database is valuable not only for the researchers but also for students who could access the newest or related results at their interests. Figure 5 illustrates the query form, where k-MST problem with NP-complete complexity and other constraints are given, and the queried result of our reference database. This service would like to attract interested users' participation to our virtual classroom where discussions via the bulletin board are welcomed.



(a) a query form

(b) the quried result

Figure 5 The query and result reference database on algorithms

5 Concluding Remarks and Future Studies

We propose the design and implementation our virtual classroom for algorithms in this paper. The cognition of algorithms might need a process of individual thinking, iterative testing and experience sharing. Our virtual classroom offers learning aids on these respects via the web. It is expected that such a learning environment could help students to learn algorithms more effectively at their own pace. The hypermedia courseware will be increased and updated as a long-term project.

The activities in the traditional classroom are simulated to a great extent in our virtual classroom. However, we are not intending to give up the face-to-face interactions. The authors applied this hypermedia courseware on web as a learning assistant in a part of this semester. Students showed interests on constructing their knowledge via the hypermedia courseware and animations. Some students expressed that they supposed to understand the recursion in quick-sort before feeding data to the interactive animation, however they found their misleading after the visualization of data movement in the animation. This is one of the benefits what we intend to give in this virtual classroom. The construction of the knowledge tree is underway to help tracing the learning pattern of learners. Also an empirical evaluation of the learning effect will be studied in the near future.

The reference database gradually gathers interested researchers' attention. The authors would express their special thanks to those who up-loaded their findings of new papers and those who gave valuable suggestions.

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Agent-oriented Support Environment in Web-based Collaborative Learning

Tomoko Kojiri and Toyohide Watanabe

Department of Information Engineering,
Graduate School of Engineering, Nagoya University
Furo-cho, Chikusa-ku, Nagoya 464-8603, JAPAN

Phone: +81-52-789-2764, Fax: +81-52-789-3808
E-mail: {kojiri,watanabe}@watanabe.nuie.nagoya-u.ac.jp

Currently, the web-based learning support systems are one of interesting and hot topics in points of the utilization of Internet and the application of computers to education. In particular, the web-based collaboration is very applicable means to make unfamiliar students, who are unknown with each other, discuss together in the same virtual interaction space. However, there are some problems derived from the gap between the real world and virtual environment: coordination for discussions, cooperative reactions, comprehension of learning progress, etc. These problems may be dependent on the fact that the actions of students cannot be influenced from the behaviors of others directly.

In this paper, we address a coordination mechanism to promote cooperative actions/reactions for progressive discussions. Our idea is to apply an agent-oriented framework to this coordination mechanism and introduce two different types of agents. One is a coordinator and the other is a learner. The coordinator monitors the learning progress of group and promotes the discussion, if necessary, so as to reach their common goal successfully. The learners are assigned to individual students, and act as interaction mediators among students in place of the corresponding students. Of course, the coordinator is a passive entity and learners are active entities in our collaborative learning space.

Keywords: **Collaborative learning environment, coordinator, learning situation, learner, personal learning history**

1 Introduction

The fast and world-wide enlargement of Internet/Intranet has made it possible that every person can interact instantly without depending on their physical locations. Also, various applications, which are available on the web environment, have been developed with respect to the content-based resource sharing, in addition to the traditional message exchanges. The web-based collaborative learning is one of applications, based on such a hot topic, and has been applied as computer-support for virtual learning space. If their computers were connected mutually through the web-based learning environment, students can discuss their common solving process successively and exchange various solving methods/ideas cooperatively. However, there are some problems to encourage activated discussions among students and make it possible that individual students should understand the correct answer and solving process effectively:

1) students may not participate into the discussion interactively because of their hesitation, derived from the fact that they are unknown with each other;

2) students cannot grasp the behaviors of others directly or indirectly because only the direct actions and reactions are observable through the interactive interface.

These problems are radical drawbacks for collaborative learning.

In order to solve these drawbacks effectively, we propose an agent-oriented support environment for collaborative learning. Of course, the agent-oriented frameworks for the construction of collaborative

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learning mechanism/environment have been already investigated until today. Florea[1] proposed a multi-agent collaborative learning environment in the web world. In this environment, three kinds of agents were introduced: personal agent which gets the information according to the requests of each student, tutor agent which generates advices when personal agents asked for the help, and information agent which acquires more information from Internet. Agents are activated by students' requests so that this system environment does not benefit passive students. Ogata, et al.[2] proposed mediator agents in the collaborative learning environment which assist students to find suitable collaborators. The mediator agent for each student holds the corresponding students' profile which indicates the understanding and interesting degrees about knowledge. When a student has problems, his/her mediator agent asks other mediator agents for the learning situations of their corresponding students and specifies appropriate students who may be able to help solving the problems. This research copes with the above problem 1) indirectly because this functionality supports to arrange appropriate learning group, but does not manage the progress of collaborative learning. Nakamura, et al.[3] and Liming, et al.[4] introduced respectively pseudo students which correspond to individual human students. These pseudo students have the same knowledge as the corresponding students and participate in the discussion in their ways if the corresponding students do not join in the discussion positively or cannot understand the discussion stage. These research viewpoints focus on passive students such as problem 1), but do not solve the problem 2). So, in spite of these various agent-based investigations, the previous drawbacks are not always overtaken.

In this paper, we address a collaboration learning environment, organized systematically under two different types of agents: coordinator and learner. The coordinator takes roles to monitor the discussion situation among students, grasp the learning progress and guide the learning process if necessary. The learners are virtual students corresponded possibly to individual students in our web-based collaborative learning environment. The coordinator and learner are complementary entities in the learning environment: the coordinator is a passive entity; and the learner is an active entity as the autonomy for practically participated student. In our investigation, we expect the collaborative learning of high school students who study mathematical exercises together, especially computation for the roots of equations. First of all, we show an overall framework of our collaborative learning environment in the web-world in Section 2. The functionalities about two different types of agents are stated in Sections 3 and 4, and then our prototype system is shown in Section 5. Finally, we conclude our paper in Section 6.

2 Collaborative Learning Environment

In the web-based collaboration learning environment, the actions/reactions of participated students are inherently different from their behaviors to be performed in the real world. Students in the physically constrained learning space can speak with each other by means of face-to-face, feel/recognize activities, occurred from the discussions of students, directly by various sensitive receptors and find out some new events/facts indirectly. Although these are not always implemented adaptively in the web-based virtual learning space, it is necessary to organize a collaborative learning environment in which the logical activities for support of interaction, discussion and comprehension can be implemented successfully and effectively.

Figure 1 shows our collaborative learning environment conceptually, which is characterized by two different types of agents: coordinator and learner. The coordinator places on the center of our virtual classroom (as a network server), monitors the interaction among students and generates advices if necessary according to the learning situation. This interaction is supported on the conversation means through the public communication line. The learner is a pseudo student in our virtual classroom and is assigned to the corresponding student one by one. The learner takes roles of the personal management of interaction interface for the corresponding student, the handshaking control of public communication line, the management of its own private learning history, and so on. In addition, the learner can communicate with other learners directly through the private talking line in order to exchange their personal learning histories.

Since students are studying with limited learning tools in the virtual web-based learning space, they sometimes do not able to communicate naturally. Furthermore, various students participate in the learning group and the learning process is not always completed successfully: i.e. some students are not able to solve the problem, some students are not able to understand the derived answering process after all, and so on. The coordinator solves such drawbacks in the virtual web-based learning space by managing the learning situation globally: the coordinator takes a place of teacher in our classroom activity. For the purpose of resolving inappropriate learning situation stepwise and guiding

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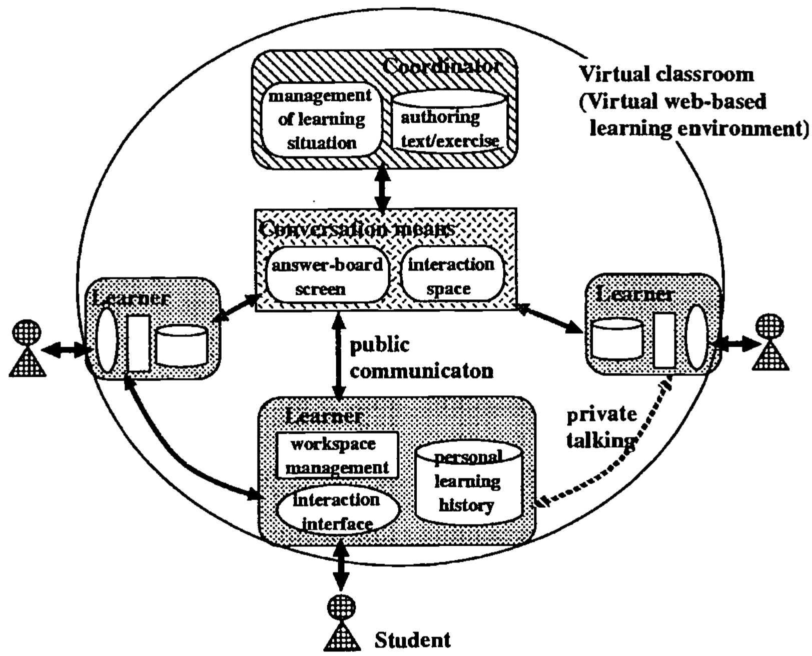

Figure 1: Collaborative learning environment

the learning group effectively, how to model and control learning situation is an important subject. If the coordinator grasps the learning situation appropriately, the advices which were generated from it may give appropriate hints in order for the learning group to proceed to the next phase of learning process. However, it is not always necessary to model the learning situation in detail precisely. This is, we think, because among the learning group students are able to help each other by discussion, so that the coordinator only has to detect the situation which the learning group cannot proceed the learning by itself.

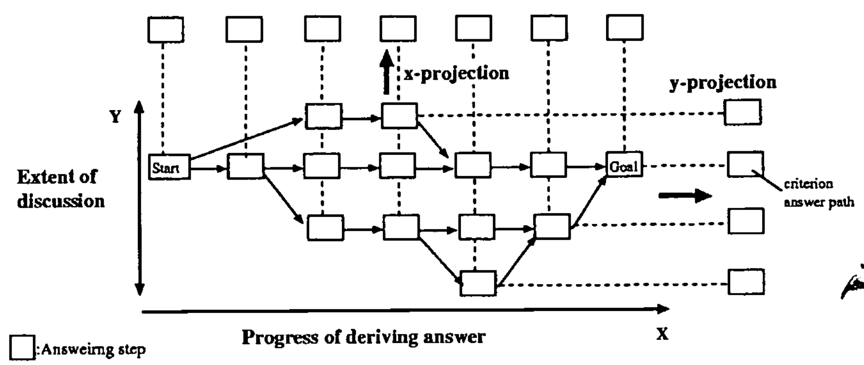

Figure 2: Answer space

The coordinator holds the right answer and the answering paths for an exercise as a knowledge to grasp the current learning situation. When the exercise has several answering paths for the goal, the answer space of exercise is expanded as 2-dimensional network structure, in Figure 2. In this figure, the learning progress along x-axis means the stepwise progress of deriving answer, whereas that along y-axis shows the extent of discussion. If the coordinator grasps the learning situation on the basis of the answering process of network structure as it were, it is very troublesome to manage the eventually changeable conversation stages successively. Therefore, our coordinator manages the learning situation with respect to the following two viewpoints separately: ratio of derived step for a whole answering process and extent of discussion. By monitoring the learning situation under these points of view, the coordinator is able to grasp the learning situation easier and generate advices timely. In particular, it is necessary and sufficient to manage the learning situation of group globally, but not individually do that of each student.

The learner acts as a network client in place of the corresponding human student in the virtual web-based learning space. This provides not only the interaction interface for virtual learning space attached to the corresponding student, but also the function of indirect interaction among students, so as to judge the understanding levels or personalities of them, which we call the focus function. According to the focus function, students select the opinions of particular students whom they evaluate as key students. In order to realize the focus function, the learner needs to have the knowledge about the corresponding student and exchange it with other learners. Therefore, the personal learning history is prepared for learner, which represents understanding level and personality of corresponding student. The learner constructs and maintains the personal learning history according to the current situation. Exchange of personal learning history is one-to-one interaction so that public communication is not necessary for the focus function. Therefore, we introduce mobile agents called mediators as children of the learner, that take responsibilities for the exchange of personal learning histories among learners. The mediator moves among learners by requesting/carrying the personal learning history on the private talking line.

3 Coordinator

The coordinator grasps the learning situation from two viewpoints: ratio of derived step for a whole answering process and extent of discussion. For the ratio of derived step, which corresponds to the x-axis of answer space in Figure 2, we have already proposed the resolution derivation scenario which represents the phases of deriving answer stepwisely [5, 6, 7]. The scenario is generated by means of projecting the answer space onto x-axis and consists of ordered states which correspond to individual phases of deriving answer. Grasping an approximate learning situation makes it possible that the coordinator generates advices timely and effectively because each state corresponds to the individual ratio of derived step. On our scenario structure, the current learning state is pointed by the indicator *current*, which points out the currently discussing stage. The coordinator infers the current state from student inputs and moves the indicator to the corresponding state. However, the utilization of only one current discussion indicator is not enough to manage the learning state of group sufficiently. In addition to *current*, indicators *upper* and *lower* are prepared for the representation of current understanding levels of learning group. *Upper* points out the state of understanding level which is estimated that best understanding student reached to and *lower* points out the state of worst understanding student did. The coordinator is able to grasp the learning situation on the basis of the relationship among these 3 indicators (Figure 3).

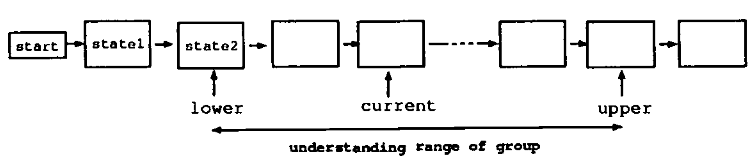

Figure 3: Resolution derivation scenario and indicators

On the other hand, the extent of discussion is estimated by the number of derived answering paths with different discussion viewpoints. The difference of discussion viewpoints among answering paths is defined as the ratio between common and uncommon answering steps. That is, if two answering paths contain large number of answering steps as common part, they are regarded as more similar paths; but if they have many different answering steps, they are judged as different paths. Common answering steps means that the answering methods which are used to derive those steps are the same. Once two answering paths were diverged, the following answering steps may be derived based on different answering methods so that they are regarded to be uncommon. From such viewpoint, the coordinator holds an answer tree which was transformed from whole answering paths as a tree structure. Figure 4 shows the construction of answer tree, derived from the answer space in Figure 2. The answering steps after the divergence are regarded as uncommon steps so that they are copied as different objects(Figure 4a). Then, the answer tree is transformed by means of collecting common answering steps for the purpose of grasping the difference among answering paths. The nodes in the tree are generated as a collection of answering steps that are common to particular answering paths and the path from root node to particular leaf node corresponds to each answering path. When the answer has been derived, the coordinator specifies derived/underived answering paths, calculates the differences between the derived answering path and other answering paths based on the answer tree, and estimates the extent of discussion.

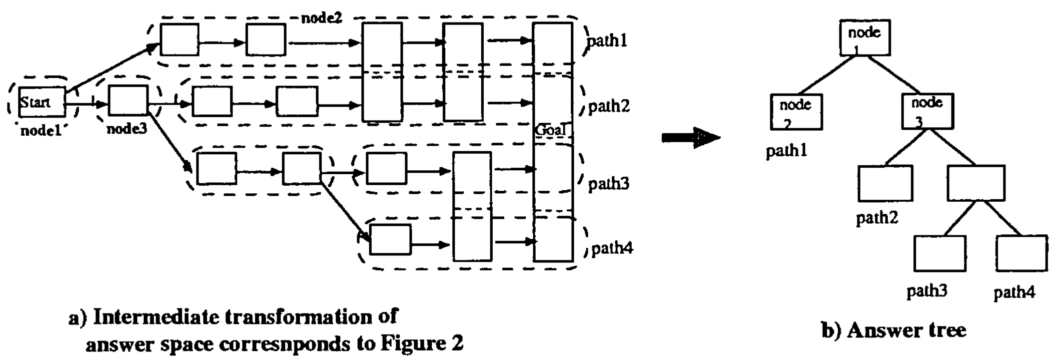

Figure 4: Construction of answer tree

By grasping the learning situation from these aspects, the coordinator is able to handle the changeable learning situation and generate appropriate advices at the right time.

4 Learner

The learner is situated on each student's computer and acts as a pseudo student in the virtual web-based learning environment. The learner provides the interface to the human student and controls the private talking among students such as focus function. Since the learner connects the private talking line according to only corresponding student's request, it behaves independently with the coordinator that manages the public communication.

A personal learning history is the model of corresponding student which is held by the learner. The personal learning history represents the understanding level and the characteristic of corresponding student. Some data of personal learning history are prepared by the human student beforehand and others are gathered by the learner occasionally through the learning. Currently, the picture and utterances of students are collected as a personal learning history. The feature of student does not change through the learning, so the picture is set by each student before the learning starts. Utterances indicate the understanding level of student and also attitude toward the learning; i.e. active or passive, understanding or not-understanding, and so on. They are gathered and added to the personal learning history by the learner when corresponding student send their opinions to the public communication line.

In order to exchange the personal learning history through private talking line, the learner generates mediators for each communication. The mediator is constructed as a mobile agent which processes its tasks while moving through the network autonomously[8]. Figure 5 shows the movement of mediator for acquiring the personal learning history of other students. When the corresponding student requests to get the personal learning history of particular students, the mediators are generated by the learner respectively. Once generated, the mediators move to the target learners through the network and ask for the personal learning history, attended inherently to the target learners. After the acquisition of personal learning history of target learner, the mediators move back to their original learner and disappear autonomously, since their roles are to acquire the personal learning history from target learners. Under such mechanism, students are able to know other students' characteristics even in our virtual web-based learning environment without any direct interaction.

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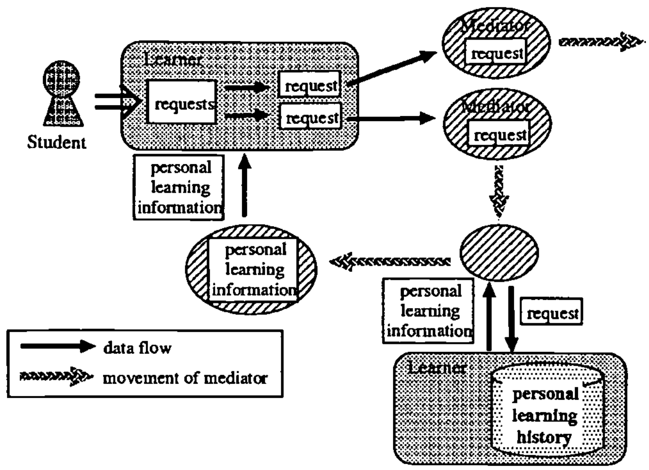

Figure 5: Mechanism for acquiring personal learning information

5 Implementation

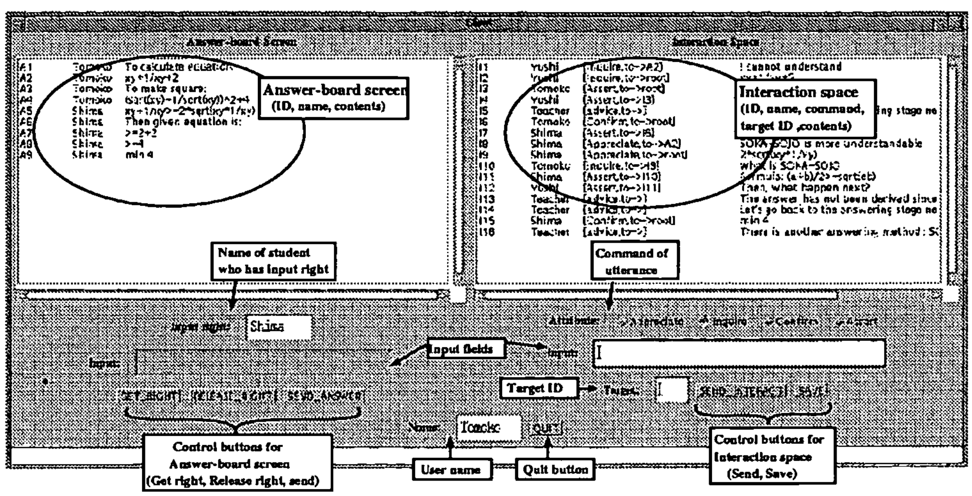

Figure 6: Interaction interface on student operation

We have implemented our prototype system on Internet using UDP protocol, since UDP protocol is suitable to control the frequent interaction of short messages. Figure 6 shows the interaction interface in our system. Two communication tools are prepared: answer-board screen and interaction space. The answer-board screen is a public communication tool which is used to arrange the group's answering process. Only one student is permitted to input on the answer-board screen at a time so that the input right is set. On the answer-board screen, ID, student' name, and contents of input is shown. The answer-board screen functions as a blackboard in our real world. On the other hand, the interaction space is prepared for free conversation so that all students are able to input freely. In order for the coordinator of our system to grasp the learning situation easily, commands that classify the opinions are introduced: Appreciate, Inquire, Confirm, and Assert. Students choose the commands when they input their opinions. In addition to the commands, students specify the target inputs which trigger off their opinions for the purpose of grasping the flow of conversation smoothly. Thus, in addition to the ID, student's name, and contents of input, command and ID of target input are also displayed on

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interaction space.

As for the coordinator, we prepared several advices which indicate the states of learning situation when the learning is proceeded inappropriately. Currently, the coordinator generates advices when it detects the following learning situation:

- learning situation has not been changed for a long time,
- some students cannot understand currently discussing stage, and
- students have not derived all viewpoints of solving the exercise.

The coordinator's objective is to activate the discussion, so the advices are generated on the interaction space as the same style as all other students' utterances. Figure 7 shows an example of advices generated by the coordinator. As for the advice, the speaker name is set as "Teacher", the command of advice is "advice", and the ID of target input is nothing because the advice is generated for the learning group but not for individual students.

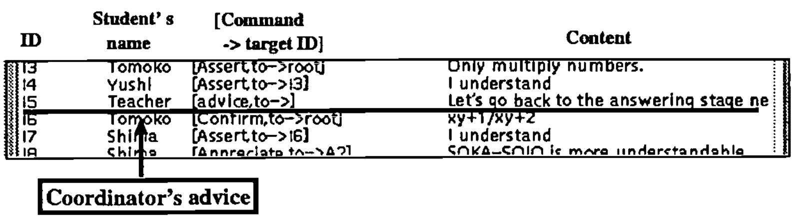

Figure 7: Advice example of coordinator on interaction space

The learners was implemented using AgentSpace[9] as a middle-ware to control the behavior of mediator. Figure 8(a) is an interface for generating requests. On the upper window, the causality of utterances on interaction space is arranged based on corresponding student's utterances. The arrangement of utterances on the upper window helps to decide the focusing students for generating requests. Once a student decides focusing students, he/she inputs IP addresses of focusing students, because mediators need IP addresses where they will work on beforehand in our current version. Then, he/she specifies the file name of focusing student's personal learning history. If a student wants to know only the particular utterances of focusing students, he/she sets the ID's of corresponding utterances shown on the upper window. Figure 8(b) is the result windows of requests for personal learning history. When requests have been completed successfully, the result windows are generated and the personal learning histories of focusing students are shown individually. Currently, the picture of focusing student is shown on the upper window and his/her utterances are shown on the lower window.

6 Conclusion

In this paper, we proposed a collaborative learning environment which contains two different agents: the coordinator and the learner. The coordinator monitors the public communication among learning group and generates advices so as to lead them to their learning goal. For this purpose, the coordinator grasps the learning situation globally from two viewpoints: the ratio of derived step for a whole answering process and the extent of discussion. Although the management structure of learning situation is simple, the coordinator may be able to find the most cases that students are not able to cope with inappropriate learning situation by themselves. On the other hand, the learner controls the private talking such as focus function. The learner holds the personal learning history of corresponding student as his/her characteristics and acquires other students' personal learning histories by generating the mobile agents called mediators. Currently, these agents function independently. However, for our future work, the interactions among coordinator and learners are necessary for the coordinator to generate more effective advices. In addition, the evaluation for the interaction interface of our prototype system and the preparation of more factors for personal learning history based on the result of the evaluation are also our future works.

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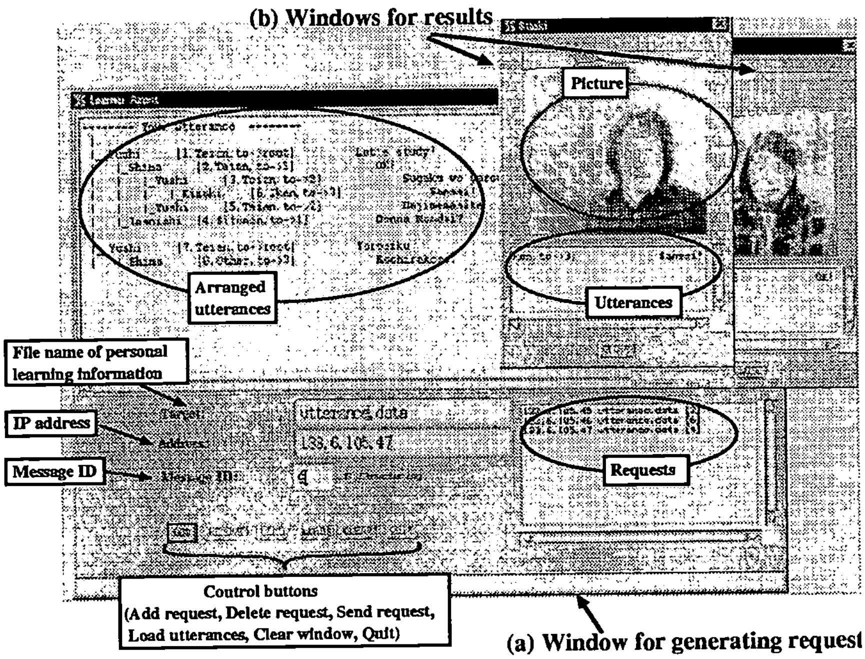

Figure 8: Interface for handling requests

Acknowledgments

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Building the Virtual Classroom for the New Millennium

Chien-chih (James) Lee, Doctoral Candidate
Technology and Education, Mississippi State University
30 H Wallace Circle, Starkville, MS 39759
cl2@ra.msstate.edu

The virtual classroom has the potential to enhance the educational productivity with a multimedia visual learning environment, broaden capability for global connectivity without the limit of time and space, and reduce costs of distribution while expanding academic territories. The main goals of this article are to identify the benefits and limitations of on-line conferencing, create a virtual classroom for interactive education on the Web, and integrate new technologies for the future virtual classroom.

Keywords: **Virtual Classroom, XML, VRML, On-line Conferencing**

1 Introduction

What is a "virtual" classroom? Can the interpersonal dynamics that occur in a face-to-face classroom be replicated in "cyberspace"? Does technology provide ways to broaden the scope and availability of training opportunities to the courts? The Federal Judicial Center (FJC) began exploring these questions in the spring of 1994 (Orlando-Morningstar & Buchanan, 1996). Web-based conferencing uses software, modems, and computers to bring geographically dispersed individuals into a "virtual" classroom for instruction, discussion, and collaboration. Use of on-line conferencing is expanding at all levels of education, particularly in higher education. This was very evident in the number of sessions devoted to on-line conferencing at the most recent EduCause Conference, "The Networked Academy," held in Seattle, Washington, December 8-11, 1998 (Charp, 1999). The virtual classroom is the concept that the world is our classroom, that distance learning serves students wherever they may be (Hawes, 1998). The main goals of this article are to identify the benefits and limitations of on-line conferencing, create a virtual classroom for interactive education on the Web, and integrate new technologies for the future virtual classroom.

2 Identifying the Benefits and Limitations

First of all, let us identify the benefits and limitations of on-line conferencing of implementing a virtual classroom in education. This is a supply and demand age. In the early 1980s, institutions of higher education began using on-line conferencing applications to deliver distance education programs. Around the same time, federal agencies, such as the Federal Aviation Administration, used on-line conferences to facilitate group discussions about process improvements and total quality service initiatives (Orlando-Morningstar & Buchanan, 1996). Today, many businesses use on-line conferencing to foster collaboration among employees worldwide. Academic institutions, such as the University of Maryland and Indiana University, offer students virtual university programs that let them attend class without stepping foot on campus. This is the future in education. The point is that we must not only need to understand society's needs, but we also have to know how to meet them. Therefore, we have to analyze and investigate the strengths and weaknesses of this system.

The virtual classroom has the potential to enhance the educational productivity with a multimedia visual learning environment, broaden capability for global connectivity without the limit of time and space, and reduce costs of

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distribution while expanding academic territories. T H E Journal (1994) points out that there are other benefits of the virtual classroom. First, students can communicate with instructors without leaving their rooms. On-line conferencing eliminates travel expenses and time normally associated with off-site training. Second, instructors can be more responsive and accessible to students with questions that will create a better learning and teaching environment. Third, the virtual classroom allows personal discussions with instructors from various locations and time zones. Fourth, the virtual classroom can complete group homework without having to meet and can also share graphical information. Fifth, students will be encouraged to ask more questions because of the reduced likelihood of embarrassment or intimidation. Finally, there will be no discrimination against race, gender, age or nationality.

The World Wide Web offers a wealth of information and flexibility to college faculty members trying to improve their courses. However, many teachers/professors do not have the time or technical expertise necessary to put their courses on the Web (Gordon, 1999). In addition, as distance learning becomes more widespread, so do sticky copyright issues (Harney, & Riichards, 1996). Most colleges and universities adhere to the same copyright guidelines in distance learning as they follow in the regular classroom. But a simple copyright infringement that may have gone unnoticed in a traditional classroom may be easily detected in distance learning programs, which, by their nature, have more exposure than regular class work. In addition, showing a copyrighted picture in a class without permission is not a copyright violation, but transmitting the same image to remote sites using technologies such as the satellite or microwave may well be an offense. And if a professor offers a class via distance learning, how can he be sure his lecture notes and class design are not being pirated by someone at a remote location (Harney, 1996). The third problem is that since on-line technology is a new teaching tool, some faculty members and learners are still using the traditional "think" style. They have felt frustrated when trying to use the on-line learning tool. Their frustration could be related to their learning styles and/or to their conservative possible personality.

3 Creating An Interactive Virtual Classroom

Another issue, we must deal with concerns plans for creating a virtual classroom on the Web. Creating the virtual classroom has a lot to offer to anyone interested in designing distance learning (Clemens, Starke-meyerring & Duin, 1999). The more careful the plan, the more efficient the outcome will be. There are three key factors that we need to understand in order to establish a virtual classroom, including dealing with audio-visual equipment, exploring some different characteristics between the virtual classroom and a traditional classroom and conducting instruction for the virtual classroom.

Audio-visual equipment must be set up in the virtual classroom. In a physical classroom there is the standard set of audio-visual equipment, and tools that are available to the instructor. These might include a chalkboard, overhead projector, video cassette player, possibly a sound system, and even a textbook. Professional instructors know how to make the best use of these tools. The virtual classroom will need equivalent equipment and tools in the form of network-based software applications. Some of these virtual tools have a relatively long history on the Internet and provide obvious applications. Others are still emerging and their potential use in a virtual classroom is not yet understood. With the appropriate design, the students should be able to take advantage of these tools without leaving the comfort of their favorite Web browser interface. Dwyer, Dan, and Doerr, (1995) assert that some of those considered for our classroom are as follows. The first is the electronic textbook. In the area of high performance computing an example of a useful electronic textbook is the Computational Science Education Project (ORNL, 1994) sponsored by the U.S. Department of Energy. The growth of electronic publishing on the Internet should ensure a good supply of electronic textbooks over the coming years. The second is the electronic chalkboard. In an electronic course, the instructor might make use of the shared whiteboard offered by a tool like NCSA Collage (NCSA, 1994) to answer a question from a student. Such tools allow images to be displayed, manipulated, annotated, and shared between two people or among a whole group. The third is a video cassette recorder and a sound system. Use of mpeg movies and audio clips can be effective additions to textual materials. Dwyer, Barbieri and Doerr (1994) point out that we might create a "cartoon" to illustrate how messages are passed between processors in a distributed system or record the animated output of a parallel trace tool. The fourth is use of a listserv to redistribute e-mail questions or an usenet newsgroup are simple methods for sharing this interaction. A more dynamic question and answer period could be created using a chat session. For some

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types of courses a multi-user, text-based virtual reality, also known as a MUD (Multi-User Domain) or MOO (Multi-user domain Object Oriented), might be effective. An example of an experiment in this area is the Diversity University (Dinsdale, 1994). The fifth is video teleconference.The ability to use video teleconferencing could enhance electronic courses not only by transferring these more subtle forms of communication, but also by providing additional visual and audio cues which help the instructor and students to form an informal rapport. Work on the MBONE (Kumar, 1994) and with CUSeeMe (Cogger, 1994) have much potential in this area.

Different characteristics between the virtual classroom and a traditional classroom must be explored. Orlando-Morningstar and Buchanan (1996) list six rules that govern the on-line virtual classroom. First, an on-line conference is more an appropriate training medium for delivering new knowledge and creating attitudinal change than a medium for building skills. Second, rich content makes for successful training. Participants will continue to log on to an on-line conference if they perceive that they are gaining some benefit from the experience. If they do not perceive a benefit, they will not come back. Third, although the heart of the program will be the on-line presentations and discussions, participants will still need note-taking guides and supporting print-based material. A schedule of program activities should also be provided to serve as virtual beacons for participants as they move from one lesson to another. Next, on-line conferences require more reinforcement than face-to-face participants. Rich content, although critical, is often not enough. To correct this, the authors assert that on-line moderators have learned to remind participants that they need to include the conference in their daily work routine. Telephone calls to non active participants are often the most effective means of reconnecting individuals to the conference. Moderators print a hard copy of the on-line group discussion and fax or mail it to all participants to help them get back into the discussion loop. These and other reinforcing activities are necessary to successful conferences. Fifth, on-line conferences need as much facilitation as do face-to-face meetings. Imagine attending a seminar where the moderator asks a question, group discussion will ensue but dies down after only a few minutes. The moderator, instead of acknowledging participant comments and summarizing the discussion, moves to another question. The participants would either find the program not very interesting or would be quite confused. Finally, some groups just do better than others. Conference moderators will always need to employ their best facilitation skills to bring a group back on track. Sometimes a group conference call will be all that is needed to do the trick.

Instruction for the virtual classroom must be conducted. Getting started may not be easy. How to use the virtual technologies in the curriculum in order to raise academic success is the point. According to Hawes (1998), the following skills are the ones that must be taught in the virtual classroom are the main things to prepare teaching in the virtual classroom. First, teach the students to use the computer. Students suffer from information overload when they first learn about computer programs. They may be learning about operating systems, software, e-mail, and the Internet all at the same time. Consequently, they need lists of steps to follow. An excellent method of computer instruction is to treat it as an independent activity. Give the students a list of steps and let them progress at their own pace. A list of practice application steps that guides them through a simple project will help reinforce the skills. Second, teach the students to search the Internet. Internet search day is even more exciting. The colors and pictures are so enticing that it is hard to get students through the lesson in the allotted hour or so, but they must learn how to use the search engines and how to type in location addresses if they are going to conduct their own searches. Third, teach the students to read the sources. In the reading/study skills classroom or lab, instructors show students how to analyze the information they find on the Internet. Selections they read on the Internet extend and reinforce textbook lessons and issues. Next, teach the students to communicate. Encourage the students to communicate with the instructor about once a week through an office/lab visit or through e-mail to share concerns, questions, or amazing discoveries. Finally, teach students to enhance functional knowledge. An excellent introduction to the Internet for instructors is Randall Ryder and Michael Graves's "Using the Internet to Enhance Students' Reading, Writing, and Information-Gathering Skills" in the Journal of Adolescent and Adult Literacy (December 1996/January 1997). These authors continue to contribute so much to the enhancement of the reading classroom.

4 Integrating New Technologies

New technologies in the future virtual classroom must be integrated. Porter (1997) offers a philosophy of distance learning, one that emphasizes the value of using technology to enhance the delivery of quality education

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and training but also suggests that educators and trainers think critically about how, when, and where that technology can best be used. As Porter explains, distance learning "requires us carefully to evaluate our instructional methods and the technologies to establish communication among learners and educators/trainers" (xvii). There are several new technologies which will be used more frequently in the future classroom.

First, XML, short for "extensible markup language", standards are too much of a good thing and are the next revolution. XML – the long awaited big brother to HTML – is becoming a reality. On June 22, Oracle announced XML interfaces for major programming languages. Jesse Berst, Editorial Director, ZDNet AnchorDesk (1999), wrote in his article " Four Reasons You're Gonna Love XML" points out the following advantages of using XML. First, a better way to search. Today a keyword search can return thousands of possibilities. Second, a better way to distribute and track information. Today it is difficult to republish content across many sites, and more difficult to track who is reading it. Tomorrow XML will make both a snap. Third, a better way to do business. Today you can browse catalogs online. Tomorrow XML tags will allow data to be customized just for you. Finally, a better way to do business...on the road. Today Web graphics bog down and slow Internet connections. Tomorrow your notebook will download only material tagged as text.

XML is based on the same basic principles as HTML, short for Hypertext Markup Language, the lingua franca of the Web. But HTML is like a generic first-grade reader: simplistic and imprecise. In contrast, XML tags information with precise descriptions that open up new worlds of possibility. After being hyped heavily as a makeover for the Web, XML is starting to measure up. The consortiums and their giant backers are weighing in. Berst J. (1999) states that there are three main events influencing impact of XML. First, Oracle's announcement XML components that interface to development languages including Java, C and C++ on June 22, 1999. Second, Microsoft is supporting XML broadly in Office 2000. Third, IBM recently announced it would deliver an XML toolkit as part of its Web Sphere Studio.

Second, Virtual Reality (VR) is more powerful in the virtual classroom than in the traditional classroom. Web pages will make alive with VRML, short for virtual reality markup language and other media technologies. VR is the love of kids even including teenage students and adult learners. Across the nation, researchers and faculty are exploring ways to turn virtual reality into a tool to enhance student learning. VR is accomplished through advanced computers that manipulate complex graphic images with sounds and other sensory information to recreate a high-sensory, three-dimensional experience for the user (Roach, 1997). Its technology can take many forms. The most advanced form, referred to as full immersion virtual reality, gives the user a full-blown experience of a unique space or location by using sensory clothing, goggles with head-mounted display, motion pads, and other special equipment. Full immersion virtual reality is used in complex training situations for flight and other advance machinery. The U.S. military has made extensive use of virtual reality technology to teach flight and combat training.

Roach (1997) points out that project ScienceSpace, a joint venture among George Mason University, the University of Houston and NASA's Johnson Space Center, is using virtual reality technology to introduce students to Newtonian physics, electrostatics, and molecular biology. The project's objective is to help students succeed at parts of the science curriculum that often discourage them from considering or completing undergraduate science and engineering majors, according to Dede. Students are taught complex subjects by being immersed in virtual reality environments that let them see and feel the dynamics of a particular subject. The environments consist of a high-performance graphics workstation, a head-mounted display for sight and sound, a magnetic tracking system for the head and both hands, a 3-D mouse, and a vest. Dede believes Project ScienceSpace can have a major impact because it's directed at students who, if they master the most abstract science subjects, could go on to become highly productive scientists, engineers, and researchers. In "NewtonWorld", the virtual reality environment for exploring Newton's Laws of Motion, students are made to see objects and feel pressure that allows them to experience the concepts of mass, velocity and energy. Institutions must devote considerable resources and funds to engage in virtual reality research. Like other advanced computer technology applications in higher education, virtual reality programs will have to undergo rigorous evaluation if they are to receive funding and support. "VR is always going to be kind of an exotic technology. It's always more expensive," Dede says (Roach, 1997).

Third, build a powerful and adaptable telecommunications system in order to build speed and volume. Hophins (1997) states that the design of a data must incorporate speed and volume. Determine how many users need to

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connect, how many to exchange information, and the projected volume of use. The traditional copper-based network often functions below today's standards for speed, and troubleshooting is difficult, which results in high system maintenance and low reliability. The most challenging information aspect is implementing a local-area network (LAN) that will function effectively into the future (Hopkins, 1997). Select the best technology the institution can afford that meets current and projected needs, keeping in mind that there will always be a new technology just around the corner. Hopkins (1997) points out that one of the current state-of the-art technologies is a LAN backbone based on asynchronous transfer mode (ATM) technology, which offers the many benefits. First, fiber-optic equipment increases system reliability. Second, a topology capable of operation uses redundant fiber paths and is capable of supporting exponentially growing data requirements. Third, a network management station monitors the network and provides warnings and alarms to alert network administrators to imminent problems with the system. Finally, a fiber -based ATM data network will support more users than the copper-based network and offer greater speed and performance.

Fourth, conferencing software plays a key role in the innovative university project. Due to an increasing number of off-campus students it was more difficult to coordinate appointments and physically meet with teaching assistants and other students. Hectic schedules the night before an exam make it hard for teaching assistants to accommodate all students and their questions. Finally, both students and teaching assistants are looking for more efficient ways to use their time. The University of Illinois at Urbana-Champaign (UIUC) states that the Oakley's conferencing program allows students to send color text, graphics, digitized voice recordings and hand-drawn equations or circuit diagrams over the network to a central bulletin board (T H E Journal 1994). A faculty member or another student can use the network to respond to a student's posting or inquiry for help, or join in an on-line discussion--all using data files, pictures and sounds. Structured on a bulletin board model, PacerForum allows many users to collaborate on various projects in different locations at different times. Students post messages that can include texts in various fonts, sizes and colors, screen shots, pen-based graphics and digitized voice recordings. The multimedia format helps facilitate clear and precise communication, especially useful in this technical discipline. The University of Cincinnati solved the problem by developing a model "virtual classroom", that can be used by anyone teaching a course at its main campus or at any of its branch campuses.

The system, known as "Classware," was developed jointly by Academic Information Technology Services and the Center for Academic Technologies (Gordon, J. 1999). That is an advantage for the students as well as the faculty. Even a faculty member who knows nothing about HTML coding can take advantage of Classware. Classware requires very little knowledge about HTML. Now publishing on the Internet is as simple as filling out a form and making a few choices. It takes about 10 minutes to set up an electronic classroom. There's no paper, no waiting in line. Other similar programs are WebCT and Bllackboard. WebCT is shorted for "Web Course Tools", which is a networked system designed to aid in the delivery and facilitation of online instruction and learning. It was developed by the University of British Columbia and is presently being used at varying levels by a variety of educational institutions worldwide. WebCT is a powerful tool that includes course design, question post, live chat, and student data management. It is charged by using a license. Blackboard can be downloaded free on the Internet.

5 Conclusion

In conclusion, the purpose of the virtual classroom is no different than that of the traditional classroom. However, life-long learning and off-campus students are increasing. Many advancement in education technologies are involved in the virtual classroom of the future. Those improvements will reinforce the education system. Curriculum Review (1998) reported that U.S. kids lead the computer technology revolution. Most American children feel quite comfortable in front of the computer screen, a recent Roper Reports Worldwide study reveals. Some 67 percent of U.S teens had used a computer in the past month. About 54 percent reported using computers at home, while 78 percent had used them at school. The virtual classroom is essential for the 21st century in education. To prepare for the next generation, we need to identify the benefits and limitations of on-line conferencing, create a virtual classroom for interactive education on the Web, and integrate new technologies in the future virtual classroom.

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Design and Implementation of A N-Tiered Heterogeneous Virtual School Administration System

Huang Gooshyon
Tamkang University Information Center
151 Ying-chuan Road, Tamshui, Taiwan 251
Tel: +886-2-2621-5656-2681
E-mail:georgehw@mail.tku.edu.tw

There are two types virtual school administration systems, web-based or voice-based, which are currently used by students. They are systems with different access mechanisms but same business logic, and require two times of resources for development and maintenance. Whenever the business logic of the systems changes, both of the systems need to be implemented. As the wireless communication grows more popular, the school has been considering adding a wireless interface to the system. However, with current architecture, the only way to add a wireless application protocol (WAP)-based system is to implement an additional system from scratch. Since the voice-based system and the web-based system have the same business logic, they can be integrated into one. We can dedicate an application server for the business logic, which interacts with the web-based interface and the voice-activated interface with a set of application programming interface (API). With the extraction of the business logic and the business logic API, developers for the voice-activated interface and the web-based interface can implement the interfaces without specific knowledge of the business logic of the system. With this design and architecture, the system can be further expanded to support a WAP-based interface and other interfaces easily.

Keywords: **Internet, wireless, virtual school, heterogeneous**

1 Introduction

The Internet is widely used for school education, especially virtual school education [2][3][4]. The advantage of the Internet is its capability of supporting multimedia and its attractiveness to the user. For the virtual school education, the students study via the Internet. They do not have to be in the classrooms of a school and can learn at anywhere at anytime. However computers and communication networks are needed to support virtual education through the Internet. The cost of the computers and setting up the communication networks is very expensive. Thus, the systems are not available everywhere. Furthermore, system interfaces must be developed in order to allow the users to access the computers and the networks. The purpose of these system interfaces is to provide an easier way for the students to access the systems and to allow the students to interact with the instructors real-time. Those systems interface do not need to be attractive and colorful since its main goal is to provide a mechanism for the students to access information real-time. For a web-based system, the homepage can be design in a way to reduce the network traffic and system load. However, not every student can access the computers and the networks due to his financial situation or the load of the system. For the students who cannot access the computers and the networks, the telephone (the voice activated based interface) provides another popular access media. Therefore there are needs for systems to support both telephone (voice- based) and web browser (web-based) interfaces [1]. The web-based system is more visual and more user friendly, however, the voice-based system is more convenient, more affordable, and requires no hardware investment from the students. As the technology evolves, the wireless communication is gradually taking over the traditional wire line communication. To support the wireless communication the system will need to be expanded to support the wireless application protocol (WAP)-based interface [10].

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Originally, a couple of the school administration systems we had can be accessed via a regular telephone or via a web browser but not both. They were basically two different systems, though they support the same business logic. Both of them have their own user interface and system logic and were designed, implemented, and maintained separately. To support them two sets of resources are needed. The original system architecture is shown in Figure 1. Developers for both of the systems handle both the business logic's and the user interface's design and implementation. Whenever the business rule changes, both of the systems need to be modified and updated. It is very costly and difficult to keep both of the system consistent.

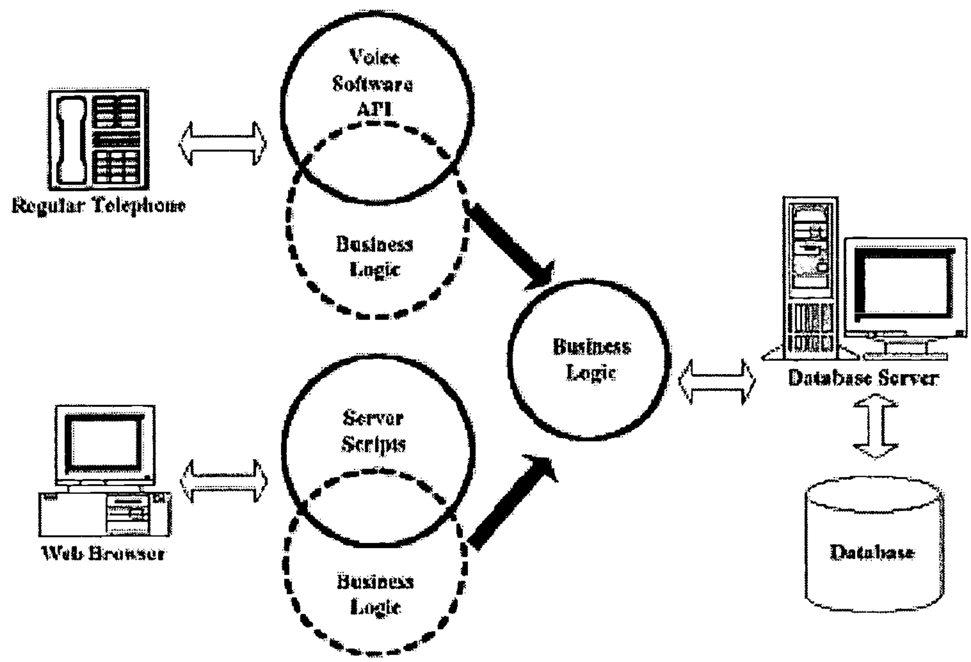

Figure 1. Logic view of voice system and web system

To reduce the maintenance cost of the two systems and to make them easier to be upgraded and expanded, we have proposed to integrate the two systems by extracting the business logic module out of them and migrate it into an application server. The remaining of the systems is migrated into a web server and a voice server respectively. By doing this, we dramatically reduced the cost of maintaining the system. After the architecture change, whenever there is a business change, only the application server is affected. We reduced the maintenance cost by 50%. No more concerns about the consistency of the systems. With the modification of the system architecture, we make it more scalable and expandable. The system can be easily expanded to support other access media without making changes to the application server. For example, to support a WAP-based interface, a WAP server can be easily introduced and integrated into the modified system architecture.

2 System Architecture and Implementation

2.1 Architecture

The administration system is an N-tiered system.

- Data Services Tier: The database services and implementations.
- Business Logic Tier: The business rule of the system.
- Translation Tier: Translate the I/O between application server and gateway server. For the voice-based system, the gateway server is the voice server. The purpose of the voice server is to translate PSTN and HTTP between application server and usual telephone. For the web-based system, the translation tier is transparent; it does not do anything. For the WAP-based system, the WAP Gateway is the gateway server. The purpose of WAP Gateway is to translate the WSP/WTP and HTTP between WAP telephone and web server.

- Presentation (UI) Tier: The input and output of the web-based system is HTML. The input and output of the voice system is the key press and voice of usual telephone. The input and output of the WAP-based system is WML [10].

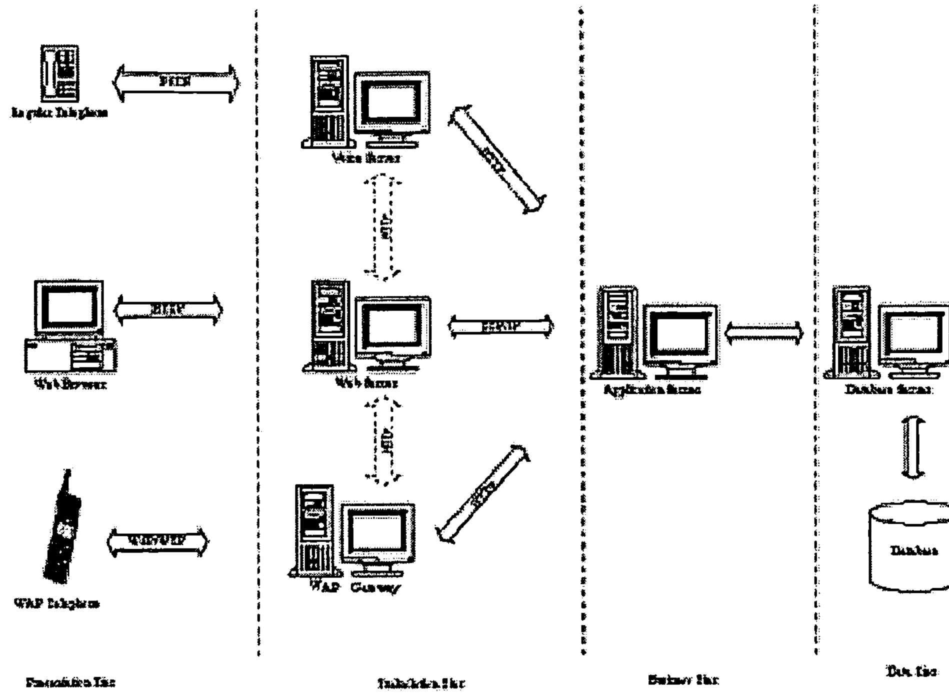

Figure 2. System Architecture

In the Architecture, the application server is the most important part. The application server needs to process business logic and interact with voice server, web server, and WAP Gateway. Because the protocol between the application server and the voice server and the WAP Gateway is HTTP protocol, we can set the application server and the web server in the same machine. The developers of the application server are more responsible, because they must handle business rule, HTML and WML. The developers of the other systems implement User Interface and do not have the knowledge of business rule of the system, because the developers of the application server handle the business rule. The application server sends different output format to different systems by parameters. Under the Architecture, after building the web system, the other systems are easily to build.

2.2 Architecture of the Voice System

Because taking business logic out of the voice system, the function of voice system is coherent. It translates the output of web server to telephone. The output format of web server is HTML. So the voice server has to simulate to web browser, shown as in Figure 3.

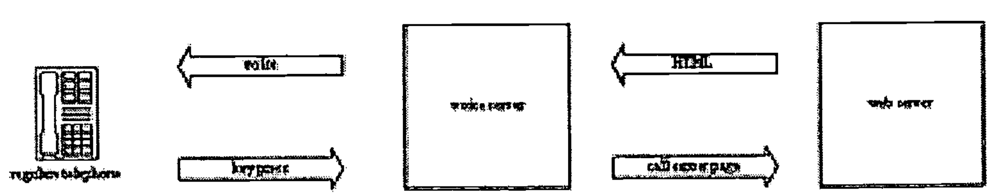

Figure 3. The communication methods are between voice server and web server.

3 Case Study

The Enrollment System of the Tamkang University [7] is designed and implemented following the architecture of this paper, shown as in figure 4. The system has been deployed and used by thousands of concurrent users [8].

3.1 Hardware Structure

We used thirteen Pentium based servers to implement the system. Six of them are used as the web servers. One machine is used as the UNIX Gateway. One server is used as the alert and automating email server. Four voice servers are used to support the voice activation. Finally, all student enrolment information is stored in one database server. The network hardware are two 100 MB/sec switch hub.

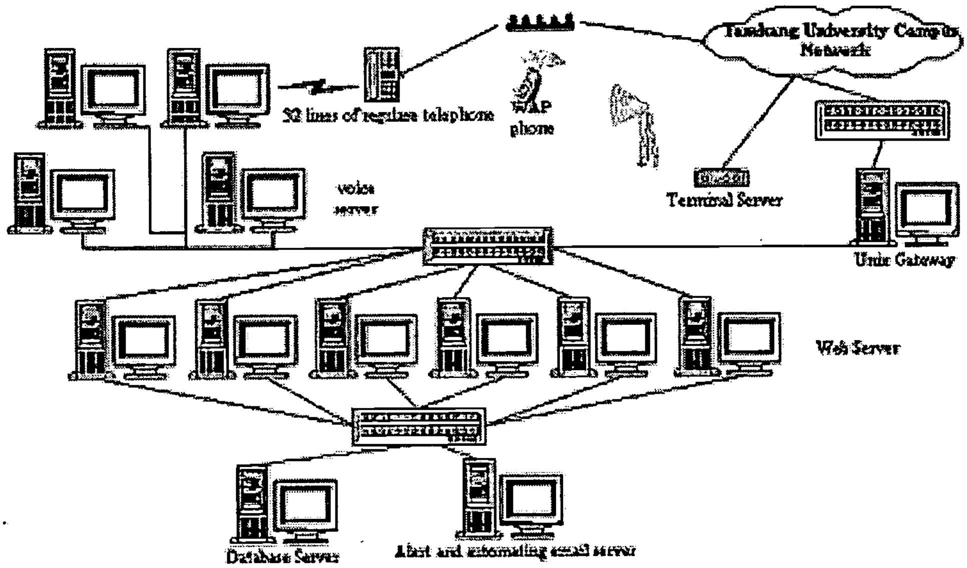

Figure 4. System Hardware Structure

3.2 System Software

OS: Microsoft NT4.0 is used for the web servers, voice servers, and the alert and automating email server. Free BSD 3.0 is used for the UNIX Gateway [8].
Web server: Microsoft IIS 4.0.
Database: Microsoft SQL Server 6.5.

3.3 Load Balancing and Scalability

To make the system suitable for all schools, we also took into considerations of the cost of hardware and the scalability of the system. A set of low-end servers can be grouped together to replace a high-end server[6]. To achieve this, a DNS server is needed for the load balancing work. The simple round robin methodology is used for the load balancing. With the current flexible four-tiered architecture, servers can be added into the system to share the performance load whenever the system load is heavy[9].

3.4. Security

Two security strategies are used to increase security:

1. Packet filter: It only allows IP packets through port 80 to access the web server, the packets of the other ports can not pass through. The web system can avoid being attacked by the other machines.
2. Supports multi-protocol: TCP/IP protocol is used between the web server and outside systems. IPX protocol is used between the web server and the database server. The web server should be hacked, the database server is kept away Internet and the database is still safe.

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3.5. Network Management and Monitoring

The alert system has the following features:

1. Monitoring the system: It sends to keep-alive message to web servers, voice servers, and database servers in every period.
2. Network management system: Checks network traffic between web servers, voice servers and database server.
3. Auto Backup the data of database server.

3.6. User Interface Design

One of the most important criteria of the virtual school administration system is to let students access and retrieve correct information real-time. The user interface must be simple to reduce network traffic and system download time. The homepages for the web system and WAP are simple and straightforward to improve system performance. The look and feel of the WAP homepage depends on the WAP telephone the user users. An Ericsson r320 model WAP homepage is shown here as a sample WAP homepage. We can compare the home pages for the web system and WAP system.

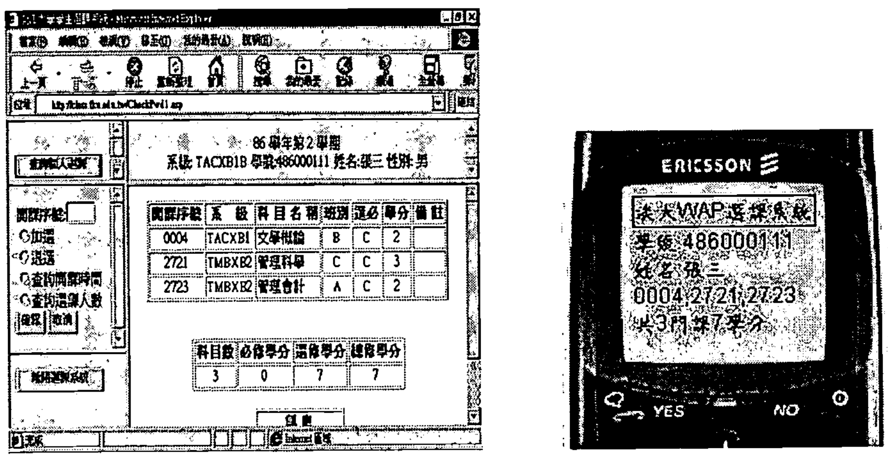

Figure 5. The display of the homepage of WAP-based system

3.7 Log statistics and analysis

Duration of enrollment period, the system generates the log automatically everyday for statistics and analysis, as shown in Table 1.

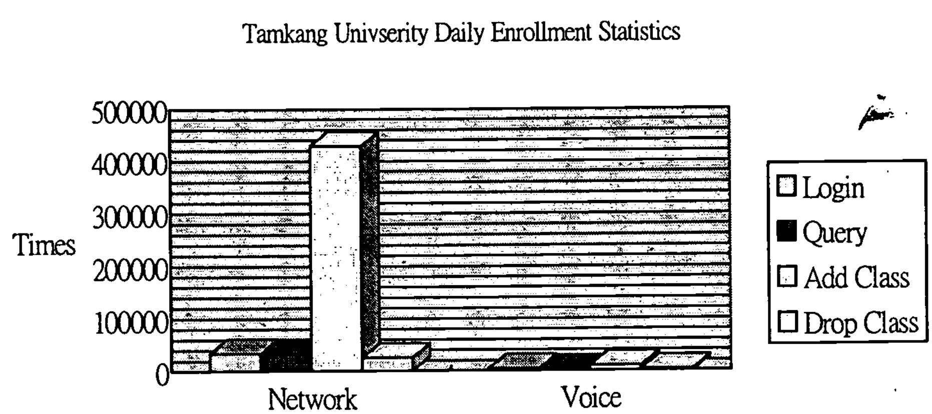

Table 1. Tamkang University Daily Enrollment Statistics

By comparison, the load of the web system is much heavier than the load of voice system. Since the voice system has 32 telephone lines, it can only support 32 concurrent users. In the peak hour of the enrollment (the first hour of each grade enrollment), the load of the web server is high.

We expect the voice system and the WAP system to be fully loaded during the peak hour. A dedicated business logic-processing server is used for the voice system and the WAP system. Since the telephone lines of the voice system and the WAP system are limited (up to 32 lines), a dedicated web server for the business logic processing of the voice system and the WAP system is sufficient.

4 Conclusions and future development

The development and maintenance resource of the heterogeneous systems depends on how many access media. The more access media, the more resource it needs. My proposal has the following advantages:

- Resource Reducing: Because the business logic is centered, heterogeneous systems need one business-logic process only, the resource of development and maintenance is less than usual systems.
- Expandability: With the N-tiered system architecture design, the business logic system was designed and implemented to support different UI systems. Different UI access method can be easily added into the system.

In the system, the application server interacts with voice server and WAP Gateway on HTTP protocol., so the application server must have functions of the web server. We can develop a new structure of the application server for voice-based system and WAP-based system, and the application server interacts with the voice server and WAP Gateway on TCP/IP.

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Developing an IT-immersion Environment to Enhance Learning and Teaching in Design and Technology

LO Ting Kau*, AU Wing Kee, and YIP Wai Ming*****
The Hong Kong Institute of Education
10 Lo Ping Road, Tai Po, N.T., Hong Kong
*E-mail: * tklo@ied.edu.hk, ** wkau@ied.edu.hk, *** wmyip@ied.edu.hk*

Design and Technology (D&T) as a school subject aims to provide learning opportunities for students to develop the technological awareness, literacy, capability and lifelong learning patterns that they need to live and work effectively in an ever changing technological society. Information Technology (IT) is quickly transforming education by breaking down the traditional boundaries of learning and teaching. This article discusses the ways that IT can be made relevant to the learning and teaching of D&T and in teacher education. It then describes the development of an ongoing project[#] which aims at developing an IT-immersion environment to enhance learning and teaching of D&T at a teacher education institution in Hong Kong. The setting up of this information-rich, collaborative learning environment is to complement "traditional" lab-based approach to learning and teaching of Computer Aided Design (CAD) and Computer Aided Manufacture (CAM).

Keywords: **IT-immersion, Learning Environment, Design and Technology, Teacher Education**

1 Introduction

Design and Technology (D&T) as a school subject "aims to provide learning opportunities for students to develop the technological awareness, literacy, capability and lifelong learning patterns that they need to live and work effectively in an ever changing technological society." [3] Information Technology (IT) is quickly transforming education by breaking down the traditional boundaries of learning and teaching. [5] IT is also being regarded as an effective tool for learning and teaching D&T in two main areas, namely:

- ***IT as a tool.*** IT can support many aspects of designing and making in D&T. For example, information processing and presentation, modelling, computer-aided design and manufacturing, control and communication.
- ***IT as a source of knowledge.*** Here, IT is being regarded as a source of knowledge to learn about materials, equipment, designing and manufacturing. This encompasses CD-ROM information systems, and the use of local or online databases accessible over the Internet. [2] [6]

2 IT in Education Policy in Hong Kong

The Hong Kong Special Administrative Region (HKSAR) Government launched its IT in Education Policy in 1998. [1] [5] According to this policy, Hong Kong teachers will be required to reach different levels of IT Competency in Education over the next few years; and IT-supported instruction will become one of the essential instructional strategies in future. Consequently, teacher education institutions in Hong Kong will be

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The project entitled "Development of an IT-immersion Environment to Enhance the Teaching and Learning of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM)" is supported by the Teaching Development Grant (TDG) administrated by the HKIEd, which is granted by the University Grants Committee (UGC), Hong Kong.

required to integrate in their pre-service programmes IT competency elements such as producing courseware, applying the skills of computer-aided instruction, and using various electronic networks for peer support and collaborative learning.

3 The Project

The following sections describes an ongoing project which aims at developing an IT-immersion environment to enhance learning and teaching in D&T at the Hong Kong Institute of Education (HKIEd), the major provider of D&T teacher education in the territory. This project is a response to the HKSAR Government's urge for the integration of IT to enhance the effectiveness of learning and teaching in teacher education institutions. [1][5] The initial target group of the project is student teachers undertaking D&T at the Institute. This target group will continually widen and might eventually include practising teachers in D&T and other technology-related subjects in Hong Kong secondary schools.

The project aims to:

- develop an IT-immersion learning environment for student teachers majoring in D&T, especially focused on areas of CAD and CAM;
- develop appropriate courseware for the enhancement of learning and teaching of basic and selected topics on CAD and CAM;
- develop an appropriate web-interface for students and staff to enhance face-to-face classroom interactions;
- enable students to appreciate modern techniques of product design and prototype making through the use of CAD and CAM technologies.

4 IT-immersion Learning Environment for D&T

Davies [4] suggests that an ideal learning environment for D&T is one where the learners have maximum autonomy and are working on self-directed projects and teachers are constantly assessing with pupils where they are and where they need to go. The IT-immersion learning environment under discussion utilises some of the attributes and resources of Web-based learning and adopts a constructivist approach to create a meaningful learning environment where learning is fostered and supported. This IT-immersion environment, we believe, would facilitates greater interaction between the teacher and students, and students and students; assist D&T student teachers transit to the new mode of learning and teaching, and enable them to develop habits of life-long learning. To effect the paradigm shift from a largely teacher-centred approach to a more interactive and learner-centred approach, it is important that D&T student teachers appreciate the need for the change and are receptive to the challenge of taking up their new role as a learning facilitator in future.

Key features of the IT-immersion environment include:

- ***Learner-centred, time and space independent learning***. With the use of Web-based instructional materials, students are allowed to progress at their own pace and at any time and space.
- ***Changing Roles of Teachers and Students***. In the IT-immersion environment, the role of the teacher changes from knowledge provider to that of facilitator and guide. Conversely, students are no longer passive learners. They become participants, collaborators in the creation of knowledge and meaning.
- ***Self-directed Learning***. One increasingly important competency in the future society will be "self-directed learning". In the IT-immersion environment, students continually learn to use IT tools for the accessing, processing, and transformation of information into new knowledge.
- ***Just-in-time Learning***. "Just-in-time learning" [7] implies a high level of individualisation and self-direction in the learning process. Each student learns just what he/she needs at the time when he/she needs it. This is a radical diversion in the instructional delivery system from place-based and time-fixed group instruction to one that is fully under learner-control.
- ***Individual differences accommodated***. Learning is a complex process that takes place as an interaction between learners and their environment. The interactive multimedia and hypermedia capabilities of Web-based and CD-ROM based instructional materials would enable student control over timing and pacing and provide interactivity and active learning.
- ***Collaborative / Cooperative Learning***. Collaborative learning in this IT-immersion environment regards that both teachers and students be active participants in the learning process. The Web, for

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instance, presents an especially good environment for asynchronous collaboration in which students work together but not necessarily at the same time. This IT-rich environment also provides ground for cooperative learning that students and teachers interact together in order to accomplish a specific goal or develop an end product which is content specific. For instance, an ad-hoc group of students, teachers, and perhaps outside experts, can come together for a particular task or design project. The group splits into distributed design teams to tackle design challenges. The design teams interact over the computer network, working cooperatively and drawing on different expertise. The design is shared over the network, evaluated, and combined into an integrated artefact or system.

It is perhaps worthwhile pointing out that in an IT-immersion learning environment, IT is still considered as a supportive tool. Its introduction supplements, and indeed may change the "traditional" learning and teaching approaches in D&T. However, it is not intended to and will not replace traditional teaching altogether. For one reason, D&T is intrinsically an action-based subject. Engagement with designing and making requires students to be active cognitively and physically. Besides, lab-based activities serve a variety of different purposes that would be unlikely replaced by other means [8], for example: (a) first hand experience of using a variety of materials, equipment and processes safely; (b) actually realise high quality products, test them and evaluate them in use; and (c) face-to-face interaction among peers and the tutor.

5 Basic Components

The IT-immersion environment comprises two major components, namely: (a) the physical component, and (b) the virtual component (Figure 1).

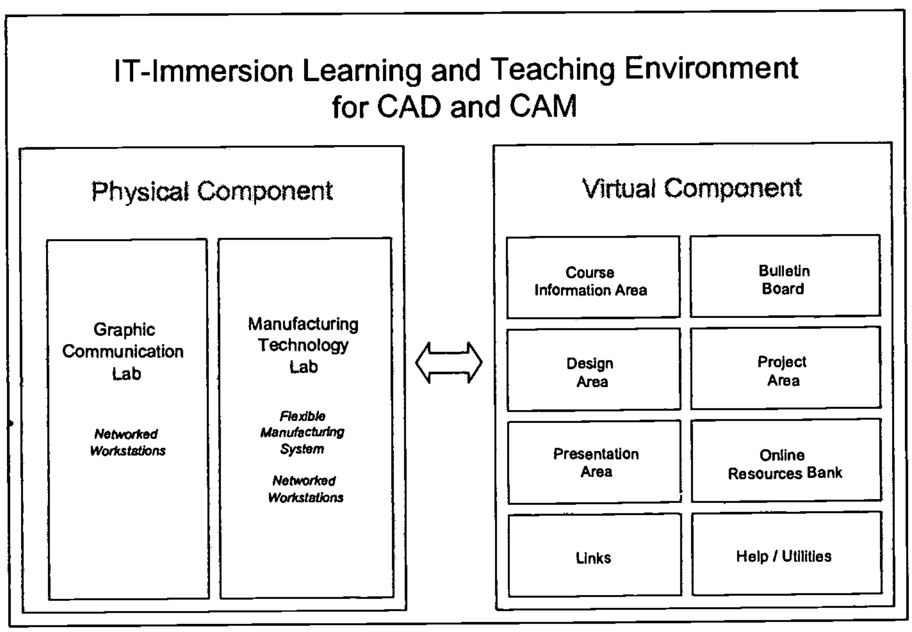

Figure 1. Major Components in the IT-immersion Learning and Teaching Environment.

The ***Physical Component*** includes facilities installed in the two labs at the HKIEd for CAD and CAM:

- ***Manufacturing Technology Lab***: A Flexible Manufacturing System (CNC Lathe, CNC Mill, and Robot), a CNC micro-router, 15 networked PC workstations, video-conferencing systems, appropriate software and peripherals, etc.
- ***Graphic Communication Lab***: 21 networked PC workstations, video-conferencing systems, digital camera, appropriate software and peripherals, etc.

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The *Virtual Component* of the IT-immersion environment include:

- ***Course Information Area*** - for students to gain access to course-specific information such as course outlines, schedules, course materials, assignments and other course-related information.
- ***Bulletin Board*** - for teachers and students to post up announcements.
- ***Design Area*** - for supporting both synchronous communication (e.g. real-time interactive chat, used to brainstorm with teachers or peers) and asynchronous communication (e.g. e-mails) to facilitate design activities. For example, students can "talk" online and discuss their design ideas via video-conferencing and/or Internet technologies with peers, teachers or experts outside the campus who can provide them with suggestion for improvement on the design. Digital cameras can be used to record the development of models/products and to present design ideas.
- ***Project Area*** that houses students' individual and collaborative design projects. A Data Bank will be set up for students to store their design works. The Data Bank will become a central design database, accessible by all members of each of the design and manufacturing teams to ensure that all team members are working with identical information.
- ***Presentation Area*** - for students to present their projects and showcase their design work beyond the classroom and to a wider audience.
- ***Online Resource Bank*** - for teachers to upload and retrieve interactive instructional and reference materials.
- ***Internet links*** - to support teachers and students using the Internet to locate professional materials and content resources in D&T and other related disciplines.
- ***Help / Utilities.***

6 IT-enhanced Activities and Learning Experiences

In the IT-immersion environment, student teachers are provided with the opportunities to use IT to explore, develop, model, communicate and realise their design ideas in a variety of ways. As such, IT becomes an integrated and natural part of their study in D&T. More specifically, to take as an example, video conferencing technology can be used as an effective medium for developing new ways of learning and teaching D&T and introducing teachers and students to various aspects of information, communications and design technologies. Using the latest information and communications technology provides the opportunity for expertise and resources to be made available to pre-service and practising D&T teachers off-campus from the HKIEd. Via video conferencing systems or the Internet, they can work collaboratively together on concurrent design projects, discuss problems and jointly solve them, and exchange ideas and information.

In brief, working in an IT-immersion environment would help D&T student teachers to understand how to become discerning users of available hardware and software. This in turn, would help them to understand what IT can and will do to enhance their future pupils' learning in D&T.

7 Conclusion

This paper discussed the potential of an IT-immersion approach to provide D&T student teachers with a richer, more meaningful education relevant for the future workplace and learning environments. It is also suggested that this IT-immersion approach can be used in a mixed-mode manner to support traditional lab-based approach to learning and teaching CAD and CAM. This adjunct or mixed-mode seems appropriate for a wide range of learning and teaching activities in D&T where real world experience and face-to-face interaction are essential. By using a mixture of traditional and IT-immersion instructional methods and tools, the learner can experience recent technology development and its impacts on learning. The point is to find out the right balance.

The project is still at its developmental stage, the effectiveness of the IT-immersion approach to learning and teaching D&T has yet to stand the test of time. However, the experience so far suggests that the project will be a success and will bring substantial benefits to both teaching staff and students.

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Development of the Web-based classroom system to be implemented by the teachers

Go Ota* and Kanji Akahori*
*Cooperative Research Center Saitama University
**Tokyo Institute of Technology
E-mail: *gohome@jona.or.jp **akahori@cradle.titech.ac.jp

The Japanese ministry of Education made an announcement that a new curriculum "Information and Computer" will be introduced nation-wide in Japan from the year 2002. Accordingly, all the schools have been rushing to deploy the personal computers and prepared to connect to the Internet through 2001. While the scope of this project aims at covering 40000 or more schools, there exists the two major problems: 1) The number of teachers who have expertise in handle the PC and the Internet, are too far short in proportion to the number required. 2) Dial-up networking prevents the students from having access to the Internet any time when they want. With a view to overcoming these problems, we have designed and developed the Intranet system or "micro Internet for classroom: mIc". The "mIc" is developed and designed to incorporate the various functions such as web-mail, electronic bulletin board "BBS", mailing list, search engine, web video conference and etc. Since "mls" consist of Microsoft Active Server Pages (ASP), it can be used from Web browsers and custom-tailored at ease.

Keywords: **Intranet, Collaboration, Video-conference, BBS**

1 Introduction

The Japanese ministry of Education made an announcement that a new curriculum "Information and Computer" will be introduced nation-wide in Japan at both the elementary school and the junior high school in 2003 and at the high school in 2002 respectively. Accordingly, all the schools have been rushing to deploy the personal computers and are prepared to connect to the Internet through 2001. While the PC have been gradually and extensively, it seems quite obvious that far small number of the teachers can handle the PC and the Internet to the contrary.

The Minister of Education has been sending the computer engineers or other computer technical personnel to school since 1994 with a view to training the teachers about the computer and the Internet. They are also required to see to it that both the teachers and the students can implement the PC and the Internet smoothly without any problems. Additionally, The Ministry has been initiating their own training programs for the teachers as well. While the project is supposed to cover 40000 schools or more, it has been experiencing the extreme difficulties of the shortage in the engineers and the technical staffs to reach out all the teachers in 4000 schools or more. It has been experiencing the difficulties as well as that Dial-up networking prevents the students from having access to the Internet any time when they want.

Despite these difficulties, it seems quite viable that all the students will get accustomed to the computer and the Internet at the earliest convenience. We, therefore, have designed and developed the Intranet System(micro Internet for classroom: mIc)

2 Design of mIc

This system "mIc" is developed and designed for both the teachers with least knowledge about the PC and the Internet, and the students as well to learn the various functions.

(a) Simulation of the Internet.
We are of an opinion that the E-mail and Electronic Bulleting Board shall be viable tools for "collaboration" among the students. Should the students require any information from the Internet, the search engine shall be inevitable to learn as well. We, therefore, have designed to incorporate these functions in the system. The teachers simply use the system without any other programs and the students can experience those functions as if they were connected to the Internet.

(b) Web-based easy operation.
The teachers can use "mIc" from Web browser. Therefore, should the teachers use the system, they can create new BBS, mailing list and registration of the students on Web based. As far as the teachers will use solely "mIc", the profound knowledge about the Internet server and the program of CGI is not necessary.

(c) Customization.
The curriculum of "Information and Computers" varies depending on the computers deployed ,the network system applied, and the objective of the education for PC & the internet in each school respectively. The system "mIc" can be customized by merely changing the text-files.

3 Structure of mIc

Considering the Standardizing the server of the average school environment, "mIc" will be installed in WindowsNT server or Window98. Please take note that less than 10 people can work with Window98 simultaneously.

3.1 ASP and COM

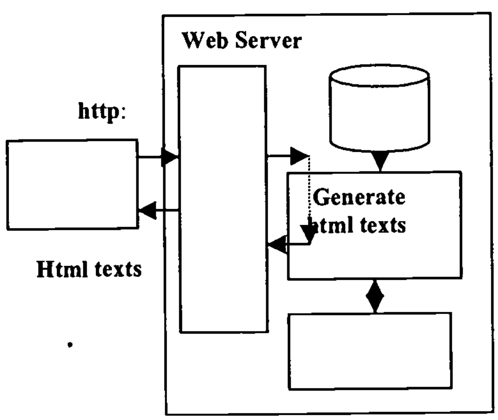

Figure 1: The Action of ASP

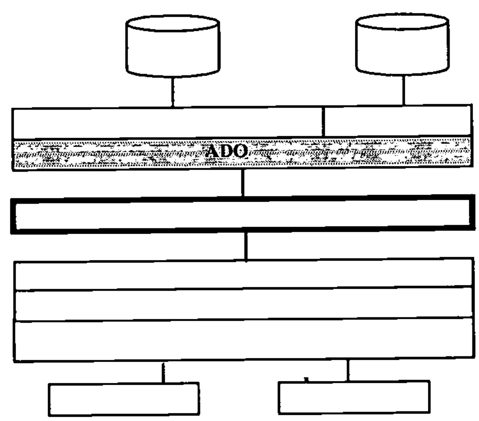

Figure 2: The structure of mIc

The system "mIc" consists of Microsoft Active Server Pages(ASP) which is the server-side execution environment. The ASP can run scripts and Component Object Model(COM) on the server . It can also easily create the dynamic contents and the powerful Web-based applications. The COM is the Microsoft software architecture that allows application to be built from binary software components. Windows itself and many other applications such as WORD, EXCEL and etc. are consisted of the COM.

Figure 1 shows the process of "mlc". ASP files appears to be the same as the HTML files but it includes additionally VBscripts or Javascripts, which call COM. At first, a browser makes a request to the server to send an ASP file in such a manner as to the HTML file. Secondly, the server executes ASP file and Bvscripts or Javascripts At last, the server send these to a browser. By using ASP, a browser only interprets common HTML without executing scripts in the client environment. Figure 2 shows the structure of "mlc". We have applied to some COM, which have access to a database, a browser, files, and a mail server. ADO is the database access COM and the system uses Microsoft Access or SQL Server.

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3.2 Setup of mlc

The system "mIc" can be easily installed by simply copying the ASP files in such a manner as for HTLM files .The teacher will be required to edit the "mIc"' configuration file which contains such information as URL, the install path and etc. Should a teacher wish to display some comments enabling the students to take note for their reference, he simply input the comments in the text-file corresponding to the exact page. The "mIc" can build more than one system in one server by creating more than one data base file.

4 System function

The functions of "mIc" will be detailed as follows;

4.1 Registration

The teachers can register the students with the use of browser. They can register even many number of students at once with the use of EXCEL or ACCESS. If the teachers will use BBS and E-mail via other programs than "mIc", they will be required to register newly each time they change the application.

4.2 System Menu

Three different user modes are available in the menu , one for a teacher , one for students and one for a guest respectively. The teacher can customize the menu for each mode. Should the teacher not use the mailing list, he can simply edit the configuration file to turn off the flag of the mailing list and the menu eventually will not display the button of the mailing list.

4.3 Web mail

The system "mIc" has two different Web mail modes whose user interface are the same , the one simulation mode and the other SMTP/POP3 mode. While the simulation mode will not actually allow to send or receive mails via the Internet, it will allow to simulate the mail functions without the mail server. Should you have the mail server and use the SMTP/POP3 mode, it will allow to send or receive mails via the Internet as the regular web mail.

4.4 Electronic bulletin board (BBS)

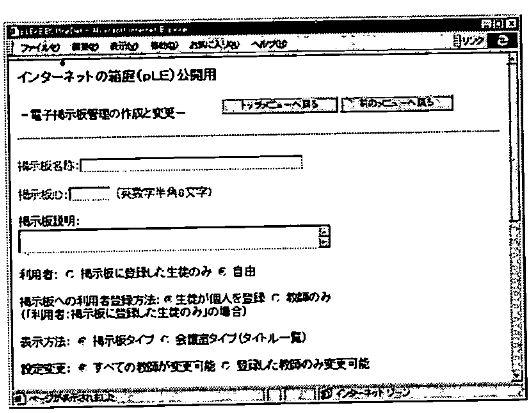

Figure 3: Screen image of Defining BBS

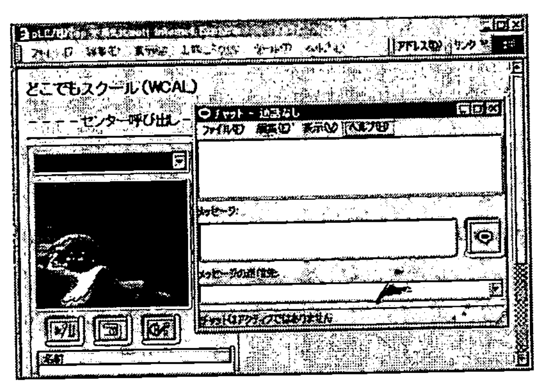

Figure 4: Screen image of Video conference

The system "mIc" allows to set up more than one bulletin board. Should the teacher wish to create a new BBS, he will be required to simply define the BBS on the browser and no new program will be necessary(Figure 3). "mIc" allows to set up the users' list covering the users who can have the access only in the BBS. The users' list can be selected in accordance with the student attribution such as Class , Group and etc.

4.5 Mailing list

The operation of the mailing list will follow the same manners as mentioned above for BBS.

4.6 Search engine

Since "mIc" has a directory service like "YAHOO" , the teachers and the students can add any new URL to the directory for their reference. If "mIc" is installed in WindowsNT server with Microsoft Index Server, the text-matching search engine can be used. The attention is drawn that "build-up of HP" has become one of the most important curriculum in Japan . The student can register their own HP's in the directory of "mls" and can subsequently search them in the classroom.

4.7 Web Video conference

Since the Video conference is very efficient and effective tool in term of the international communication, we have designed to incorporate the function "Web Video conference" in the system so as to suffice in this respect(Figure 4). A student can communicate with other students and visualize them via web video conference and refer to the data interactively via web data conference. Data conference allow the students to collaborate on "chat", "whiteboard" and "program sharing" without Video and Audio. Since the web videoconference is based on Microsoft Netmeeting 3.0 Active X, the multipoint data conference is possible and thus more than one student can participate the meeting simultaneously.

4.8 Generator of the questionnaire

Understanding strongly the importance of the questionnaire so as collect of the opinion from the students for various topics, "mIc" is designed to generate automatically the questionnaire in the form of HTML and ASP files. The teacher can easily make these files by filling in to the points raised as question on the web pages . The form filled in by the students can be saved to the text file in the form of the spreadsheet such as Excel.

5 Further development(future work)

We have already started to introduce the system"mIc" at schools ranging from the junior high school through the university . Having learnt from the experience, it seems very obvious that the teachers can make BBS and use search engines at ease. Through the continued experiments, we are prepared to improve the system further.

mIc Web Site (In Japanese)
URL www.jona.or.jp/~gohome

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Models and Strategies for Promotion of Distance Learning in Primary Schools and High Schools

Jia-Rong Jerome Wen * Chia Chin Li and Jian Jie Dung***
**jerome@nknucc.nknu.edu.tw djj@icemail.nknu.edu.tw*
116,Ho-Pin 1st Road,Kaohsiung,Taiwan,R.O.C
***april@ficnet.net*

The information education in Taiwan has been progressing rapidly since the Network Technology was adopted on a large scale.Under the Nine-Year Consistent Courses policy the by Ministry of Education, the information education will be integrated into other subjects and all teachers need to use computer and Internet resources to assist teaching .The plentiful education web sites on Internet also provide the student with materials for assisting learning .The essay presents the development process of information Education in Taiwan ;through it, we point out the obstacles we meet when promoting information education in primary schools and high schools.Meanwhile ,through introducing two education web sites :Gas Station for Learning and Schoolfellows' English Adventure Land, which were constructed in different models ,we offer the workable models and strategies for promotiing distance education in primary schools and high schools.

Keywords: **Distance Learning, Nine-Year Consistent Coures ,Teaching Material Resources Center, Schoolfellows' English Adventure Land**

1 Introduction

1.1 Analysis of Current Situation

"Nine-Year Consistent Syllabus" implemented in 2001, all schools will no longer especially establish the subject of Information Education, but enlist it in the learning area of "Nature and Technology." Nevertheless, in order to train students to have the basic abilities to make use of technology and information, teachers have to emphasize the application of information in the teaching of different subjects. And all teachers of different subjects are expected to take computer as a tool of instruction, integrate via network the traditional teaching materials and the teaching materials on Internet, and provide students with broader and more diversified learning resources.[2][3]

1.2 Problems Faced by Distance Learning:

To apply information education to the teaching of various subjects will really be a consistent trend in the education of Taiwan in the future. However, when confronted with the important educational reform, the actual implementation encounters difficulties because of Taiwan's restricted environment for information education.

The ratio of the number of class computers to the number of the students of a class is such a wide gap.If teachers are requested to use the limited computer classrooms to apply information to the teaching of various subjects, obviously, it is not an easy job to promote this at the current stage.[5][7]

2 Distance Instruction and Distance Learning

After the Ministry of Education implemented "Foundation Establishment Plan of Information Education," the computer and network equipment of various schools are increased. Besides, it also promotes the establishment of "Information Education Software and Teaching Materials Resources Center" at primary schools, junior high schools, senior high schools and vocational schools, in order to enrich the network teaching materials for subjects of primary schools and high schools.[1][8]

Besides, the famous distance instruction network of primary schools and high schools in Taiwan is illustrated as follows (Table1):

Web Site Name	Address	Institute	Object
Gas Station of Learning	http://content.edu.tw	Ministry of Education	Grade 1 to 12 student
Schoolfellows' English Adventure Land	http://192.192.186.8/seal/	San Hsin Institute of Housework and Commerce	Grade 1 to 12 student
Pathfinder	http://pathfinder.ntntc.edu.tw/	National Tainan Teachers College	Grade 1 to 9 student
Computer Assisted Instruction	http://www.wcjs.tcc.edu.tw/	Wu Chi Junior High School	Grade 7 to 9 student
Teaching Resource	http://www.ctjh.tpc.edu.tw/ctjh/resource.htm	Chiang Tsui Junior High School	Grade 7 to 9 student

Table1: Virtual Classroom Web Site for Grade 1 to 12 student

3 Teaching Materials Resources Center Focusing on Systematic Subjects

3.1 Concept and Idea:

The Ministry of Education in Taiwan starts "Foundation Establishment Plan of Information Education" not only to establish hardware environment, train teachers, carry out promotion activities, etc., but also to establish Information Education Software and Teaching Materials Resources Center, simply called "Education Resources Center" or "Gas Station of Learning."(http://content.edu.tw)

3.2 Outline of Resources Center:

The Ministry of Education advises various school to develop the on-line teaching materials of different subjects. The center can effectively integrate the resources of all primary schools and high schools and develop a series of network instruction resources with its own characteristics. "Teaching Materials of Subjects" are divided into four divisions: primary school, junior high school, senior high school and vocational school. In each group there are: 14 subjects in primary school, 19 subjects in junior high school, 17 subjects in senior high school, and 21 subjects of 4 categories in vocational school (the divisions of senior high school and vocational school was established in January 2000). The information integrated and collected by web sites cover the education resources of the Chinese's Five Education: virtue, wisdom, physical, group and aesthetics.

Through a united interface of users, it decreases the learners' load in adaptation to learning environment. The establishment of "Education Resources Center" is expected to achieve the following objectives: [6]

- Strengthen the applied network resources for teachers and students, and make the educational environment more diversified .
- Lay a foundation for a lifelong learning environment.
- Strengthen the quality and quantity of the resources of information learning so as to reach the aims of sharing of resources
- Shorten the distance between city and village [1]

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4 Schoolfellows' English Adventure Land Focusing on Self-Learning

4.1 Concept and Idea

Teaching Materials Resources Center mainly edits the teaching materials according to the contents of the systematic teaching materials of various subjects. Therefore, they are suitable for teachers to adopt in class and for students to review after class. However, in the age of information explosion, the knowledge in books can no longer satisfy most of the students' thirst for knowledge. Therefore, with network being the media, distance education must have more diversified contents. It also has to create an interacting relationship between school and students. It can hold various kinds of activities and offer substantial awards to encourage all the students to participate. Then an activated distance learning environment can be created beyond system. Kaohsiung municipal government is positively involved in the activity. The "Schoolfellows' English Adventure Land , SEAL "(http://192.192.186.8/seal/) established by the municipal government at San Hsin Vocational School is based on this idea. It has the following characteristics :(1)Diversified Contents and Scope.(2)Individualistic Learning Environment.(3)Internet Learning without Limitation of Time and Space. (4)Flexibility of Time, Holding of Activities.(5)On-Line Contest,Internet Pen Pal Society.(6)Teacher Mechanism--Student Groups Management and Inquiry of Students' Learning Process:,Self-Made Test Paper Management:

4.2 Evalutaion on SEAL

The working group of Seal held an investigation in December 1999, towards the junior and elementary school teachers that used this website to assist their teaching. The questionnaire adapted Likert's five point scale from extremely disagree(1) to highly agree(5). In the 73 effectively retrieved questionnaires, there're 67 English teachers and 6 are not English teachers.

The statistics results of the questionnaire, in the curriculum arrangement and management session, show that sample teachers think the arrangement of the curriculum in SEAL is appropriate and the related activities that go with the curriculum is successful. (M=4.10 ,SD=0.82) ◦ Sample teachers think that the recording of learning profile on the website of each student helps teachers to understand the student's learning style and problems. (M=4.26,SD=0.83) ◦ Sample teachers think that the idea of designing language games and holding on-line composition contest is appropriate. (M=4.16,SD=0.83 ;M=4.03 ,SD=0.93) ◦ About the learning interaction, most teachers thinks that English pen pal club will help to enhance the interaction between students, M=4.18 SD=0.93) . Most teachers think that SEAL is worth popularizing in assisting traditional learning. (M=4.59,SD=0.66) ◦

5 Workable Model and Strategy

In the implementation of distance education in primary schools and high schools, besides the consideration of the contents of teaching materials, how to make use of the characteristics of Internet appropriately to activate instruction is an important topic that cannot be neglected for discussion. Focusing on the above-mentioned analysis, we propose a model and strategies for distance learning be carried out in primary schools and high schools:

5.1 Four Elements for Activating Web Site:

According to the discussion above,there are four elements to activate the web site teaching materials :the content, interactivity, learning profile and activity. We have to take these four elements into consideration when designing the learning web site. The detailed function of the four elements is as follow:

5.1.1 Content

Text, image, sound , photo , animation chip and other mutimedia components should be included in an excellent education web site.Through multiple information styles supplied , the student can obsorb knowledge easily

5.1.2 Interactivity

With more interactivity function the education web site is more attractive and effective .The interactivity machanism encourages the student to use higher -level cognition skill..

5.1.3 Learning Profile

The learning profile lets the student know what he has learned and what to learn .The porfile also provides the teacher information about the student.

5.1.4 Activity

Not only in classroom but also in virtual classroom, well-designed activities are very important to improve the effectiveness of learning . Besides, through holding an activity , the student can cooperate and compete with others .

5.2 Strategy for Promoting Distance Learning

From this point of view, we will suggest applicable strategies for school administrators,teachers and students.

5.2.1 As for school adminstrator:

∗ Establishment of Web Site by Full-time Professionals:
The school administrator should know there should be full-time professionals to put teaching materials on Internet, hold Internet activities and carry out the maintenance work of systems.

∗ Strengthening of Propaganda:
The education departments or general affairs units of schools should positively introduce such an environment in the learning of students, and positively hold activities of relevant kind.

5.2.2 As for teacher and related professional:

∗ Development of Excellently Activated Web Site:
A web site must have substantial contents , diversified activities as well as interactivity machnism and learning profile to make the web site become a dynamic and lively learning environment.

∗ Material Making:
Teachers need not learn the establishment of web site. Teachers' job should be an all-effort studying of suitable contents of teaching materials for the learning of students.

∗ Resource Assisted Teaching:
All the related teaching web sites need the teacher to use them .Many web sites are well constructed ; however,few teachers use it to assist teaching . The teacher can provide the web site constructor with feedback for promoting the funciton or the rescources of the web.

5.2.3 As for Students:

∗ Participate in activities :
Only students' participation can make web sites activated and meaningful; otherwise, web site is merely an empty shell in a waste of information development.

∗ Resource Assisted Learning:
The student can make good use of on-line material to assist learning after class ; meanwhile , the student's feedback also helps the web constructor refine the web .

6 Conclusion

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After the implementation of "9-year consistent" new syllabus in primary schools and junior high schools, information will be applied to various subjects and the application of network resources will become broader. The information-application-oriented network learning functions can be facilitated more effectively. The "Plan of Teaching Materials Resources Center" undertaken by Ministry of Education integrates various schools' resource to establish a garden that provides teachers with instruction resources and students with learning resources.The Plan not only can reach the purpose of resources sharing, but also decrease the load of learning through united interface environment. Besides, the distance learning environment beyond system, as provided in "SEAL," is also a good example for primary school students and high school students to involve in distance learning.

In term of positive implementation of information education, it is important to cooperate with the existing instruction environment and choose a workable model. For the government, based on the principle of effective utility of resources, it is necessary for her to integrate the establishment and the sharing of instruction resources. For schools, they have to encourage teachers and students to use Internet positively to assist in their teaching and learning. For teachers, they might not be required to allocate teaching materials on Internet, but they have to use the existing Internet resources and teaching materials positively, adopt suitable instruction methods, and correctly use Internet to communicate with students or parents. For students, they should meet the instruction of schools, use the teaching materials on Internet to assist in their learning, and learn new knowledge themselves.

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Monitoring and Verifying Mathematical Proofs Formulated in a Restricted Natural Language

Peter Schmidt
Department of Computer Science, University of Bonn
Römerstr. 164, 53117 Bonn, Germany
E-mail: peter@uran.informatik.uni-bonn.de

A restricted natural language is presented which is suitable for formulating mathematical proofs in the domain of calculus. A line of a proof according to the language consists of three parts: A marking, a proof statement, and a foundation of the statement. Foundations include among others the name of a theorem, the name of a concept, or a formula manipulation operation. It is demonstrated how mathematical proofs worded in that language may be automatically monitored and checked for correctness and completeness by a computer program. For that, techniques of the fields of theorem proving and of formula manipulation are applied; the lines of the original proof are transformed into a quantifier free form and checked line by line; an internal knowledge base of concepts and theorems allows for verifying proof statements which are founded by concept definitions or theorem applications. The described methods may be used in virtual or face-to-face universities for the purpose of proof exercises by students or for the purpose of automatically checking and scoring student proofs. The approach together with a medium-grained XML representation of concepts, theorems, and proofs may form the core of a learning environment which gives students the opportunity of an intensive interactive occupation with mathematical proofs.

Keywords: **Calculus Proofs, Verifying, Restricted Natural Language**

1 Introduction

Finding and constructing mathematical proofs are standard activities of persons who study mathematics or disciplines of science. For learning purposes, it would be desirable to have an interactive software system into which students could enter a mathematical proof in the usual way utilizing the natural language and the software system would monitor and verify the student's proof or provide help if needed.

From the side of the field of mechanical theorem proving, techniques and procedures are available to automatically prove theorems or check a given proof, if the theorem or the proof are worded in a formal language like first order logic or the quantifier free clause form (see e.g. [1], [5]). The main bottleneck to reach the above mentioned goal is the difficulty of processing and correctly understanding natural language input. As a solution to the problem or as a compromise we here suggest a restricted natural language to formulate proofs. The language results from an inquiry into mathematical proofs which occur in mathematical textbooks of the domain of calculus (see e.g. [8]). We chose the domain of calculus because of the importance of calculus for the edifice of mathematics and for many practical applications and because calculus belongs to the first fields which are studied at the universities.

Secondly, we discuss how proofs utilizing that restricted language may be automatically monitored and checked for correctness and completeness by a computer program. To monitor a proof, the proof is transformed into an internal form which includes the quantifier free notations of the occurring logical expressions. A proof is checked line after line like a human would do who tries to verify a given proof. The checking for correctness of the single statements relies on the techniques of the fields of theorem proving and of formula manipulation and of their combinations. Regarding the theorem proving techniques we utilize methods which are similar to the methods of Bledsoe, Boyer and Henneman to automatically prove limit theorems ([2],[3]).

Apart from providing opportunities of doing proof exercises, the described methods may be used in virtual or face-to-face universities for the purpose of automatically checking and scoring proofs of students.

Thirdly, we shortly discuss the extension of the approach to an extensive learning environment.

2 Mathematical Theorems and Proofs in the Domain of Calculus

The *subjects of calculus* include among others limits of sequences and functions, derivations of functions, determination of properties of functions, integrals, the study of special classes of functions, and many practical applications of theoretical results.

Proof methods used in calculus are multifarious and include direct proofs using the analytical definitions of concepts like limit, continuous or differentiable (epsilon-delta notation), inductive proofs, indirect proofs or proofs by counter-examples, or direct proofs utilizing chains of inferences of already proven theorems.

A large set of proofs in the domain of calculus follows a recurrent pattern. One characteristic of those proofs is the use of analytical definitions of the main concepts to establish the proof. A further characteristic of many proofs is that they employ formula manipulation methods as a central technique to establish the proof. Proofs often consist of a construction process. Those characteristics allow for monitoring proofs without a long chain of logical deductions.

3 A Restricted Natural Language to Formulate Proofs

The restricted language to word proofs is here informally described mostly by examples so that persons who are familiar with proofs of the domain of calculus can understand the scope of the various allowable statements. The language is not supposed to be exhaustive, but the current version of the language covers a large set of calculus theorems and proofs in textbooks and in collections of exercises.

The usual structure of a natural language proof in a textbook consists of a series of statements which are substantiated by one or more foundations. The statements may have a reference to other statements of the proof. The restricted language reflects that structure by dividing a proof into proof lines. Each proof line consists of up to three parts: a marking, a proof statement, and a foundation of the proof statement. By clearly separating the three parts of a proof line from each other, the variety of natural language wording reduces to a simple and easily comprehensible structure.

3.1 The wording of a proof

Basic elements of the language. There are a series of basic elements which may occur in a proof including numbers, variable names, function names, the universal quantifier (ALL), the existential quantifier (SOME), and the logical operators of negation (NOT) and of conjunction (AND). R denotes the real numbers. *Keywords* of the language generally consist of capital letters. *Intervals* play a central role in proofs and may be designated in the usual way, e.g. [a,b] for a closed interval of the real numbers, (a,b) for an open interval, or ALL x WITH |x-a|< delta for an interval with the point a in the middle of it. *Partitions of intervals* are often used in various contexts. They usually define end points and a list of intermediate points and fix the length or a maximum length of the resulting part intervals (see an example below). *Iterations* may be used in the usual way, e.g. i=0,...,n or j=1,2, ... to denote a finite or infinite sequence.

Proof statements. The current version of the language comprises the following proof statements which are described in the next paragraphs:

(1) Assignment statements. Assignment statements allow for defining new variables or functions. An assignment statement starts with the keyword LET. Examples are

LET delta = min(delta1,delta2),

where min denotes the minimum function and delta1 and delta2 are earlier defined variables, or

LET h(x) = f(x)+g(x) ALL x IN [a,b] , where the new function h(x) is defined, or

LET f : [a,b] -> R , where a function and its domains are defined.

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(2) Choice statements. Choice statements describe a choice of an entity from a set of possibilities. A choice may e.g. refer to a number chosen from an interval or to a partition of an interval. A choice statement starts with the keyword CHOOSE. The format of such a statement depends on the choice situation. Simple examples are

CHOOSE eps > 0 or CHOOSE x IN [a,b].

An example which covers the choice of a partition of an interval is

CHOOSE PARTITION p OF [a,b] WITH $a=x_0 < x_1 < ... < x_n=b$ AND ($|x_i-x_{i-1}|$ < delta , i=1,...,n) ,

where [a,b] is an interval, x_i are points in the interval, and the mentioned restriction of the lengths of the intervals $[x_{i-1},x_i]$ holds.

(3) Relational statements. Relational statements, i.e. equations and inequalities, frequently occur in calculus proofs. The statements often include constraints on the appearing variables. Typical recurrent examples relate to analytical definitions of concepts and formula manipulation operations. An example which states the definition of continuity is: ALL eps > SOME delta >0 ALL x WITH |x-a| < delta: |f(x)-f(a)| < eps. Often a chain of equations and inequalities appears like ALL x IN [a,b]: |f(x)+g(x)| <= |f(x)| + |g(x)| <= M+N < INFINITY . Another simple example of a relational statement is eps/2 + eps/2 = eps , where eps is a given variable.

(4) Property statements. Property statements describe a property of an entity, e.g. the property of a function to be continuous in an interval. An example is: f IS continuous IN [a,b]. Other properties which often occur in calculus proofs are e.g. uniformly continuous, monotonously growing, or differentiable.

A series of **further statements** which often appear in a proof more or less drive or structure the proof.

(5) Proof type statements. A *proof type statement* characterizes how the proof is done, e.g. by finding a contradiction. The statement starts with the keyword PROOF TYPE and is followed by the name of a proof method from a list of proof methods, e.g.
by DIRECT, DIRECT_BY_DEFINITION, DIRECT_BY_A_CHAIN_OF_THEOREMS, INDIRECT, COUNTEREXAMPLE, SPECIALIZATION, COMPLETE_INDUCTION. The classification of the proof may be relevant regarding several aspects which are mentioned below. An example of a proof type statement is: PROOF TYPE INDIRECT.

(6) To prove statements. *To prove statements* are used to specify what must be or will be proven. There are two variants which may precede a statement: *to prove* or *sufficient to prove*. Here are examples: Let us assume that the conclusion of a theorem is: 'The function f(x) is bounded in an interval [a,b]'. Then the first line of a proof may be e.g. TO PROVE SOME m > 0 ALL x IN [a,b]: |f(x)| < m or the first line of the proof may be e.g.

SUFFICIENT TO PROVE ALL x IN [a,b]: |f(x)| < 1 . In the first case the keywords are followed by a statement which is equivalent to the conclusion of the theorem. And in the second case the keywords are followed by a statement from which the conclusion of the theorem may be inferred.

(7) Assume statements. *Assume statements* are mostly found in indirect proofs. They then state the negation of the statement of the theorem. The statement starts with the keyword ASSUME and there follows another statement. An example is ASSUME NOT [c] , where [c] denotes the marking of the conclusion of the theorem (see an example in Theorem 2 below).

(8) Contradiction statement. A *contradiction statement* states the contradiction of statements occurring in the proof. The statement starts with the keyword CONTRADICTION and its foundation contains the contradicting statements in one or the other way. An example is CONTRADICTION {[4],[6]}. The statement says that the statements marked by [4] and [6], respectively, are contradictory (see an example in Theorem 2 below).

(9) Anchor statements and **induction step statements.** *Anchor statements* and *induction step statements* serve the purpose to structure induction proofs. The statements start with the keywords ANCHOR and INDUCTION STEP, respectively. Examples are ANCHOR n = 1 and INDUCTION STEP n TO n+1.

(10) Proof finishing statement. The *proof finishing statement* consists of the keyword QED and states that the proof is assumed to be complete.

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Markings. *Markings* serve the purpose to mark statements so that other parts of the proof may refer to the marked statement. The markings consist of letters and digits embraced by brackets, e.g. [A].

Foundations. A *foundation*, possibly together with other foundations, substantiates a proof statement. There are a couple of possibilities of denoting a foundation: A foundation may consist of the name of a theorem, of a formula manipulation operation, of a property of an object, or of a line number which denotes a logical line of the current proof or of the theorem. The foundation of a logical proof line is enclosed in curled brackets whereby the single foundations are enclosed in brackets and separated by commas, e.g. {[4], [5]}.

3.2 Examples of user proofs

The following examples illustrate the use of the language to formulate proofs. Note the more often occurring *double points,* e.g. one in the proof line which is marked by [2]. That double point is necessary for reasons of uniqueness to separate the prefix containing the quantified expressions from the inequality. An alternative would be to use an IF ... THEN ... statement. The foundations starting with the letters *fm* refer to formula manipulation operations, e.g. {[fm: rewriting]} in line [7]. The theorems are here not worded according to the language. A corresponding wording is necessary when the theorems and the proofs are automatically processed by a monitoring program.

Theorem 1 (Sum of continuous functions)

```
Let
  [p1] f: R->R,   g: R->R,   a in R,
  [p2] f is continuous at the point a
  [p3] f is continuous at the point a
Then
  [c] f+g is continuous at the point a
```

Proof:

```
[1] PROOF METHOD DIRECT_BY_DEFINITION
[2] TO PROVE
    ALL eps > 0 SOME delta > 0 ALL x with |x-a| < delta : |(f(x)+g(x)) - (f(a) + g(a))|< eps {[c]}
[3] CHOOSE eps > 0
[4] SOME delta1 > 0  ALL x with |x-a| < delta1 :  |f(x) - f(a)| < eps/2  {[p2]}
[5] SOME delta2 > 0  ALL x with |x-a| < delta2 :  |g(x) - g(a)| < eps/2  {[p3]}
[6] LET delta = min(delta1,delta2)
[7] ALL x IN R : |(f(x)+g(x)) - (f(a) + g(a))| = |(f(x) - f(a)) + (g(x) - g(a))|  {[fm: rewriting]}
                                              <= |(f(x) - f(a)| + |g(x) - g(a)|   {[fm: triangle inequality]}
[8] ALL x with |x-a| < delta : |(f(x)+g(x)) - (f(a)+g(a))| <= |(f(x)-f(a)| + |g(x)-g(a)| {[7]}
                                                          < eps/2 + eps/2  {[4], [5]}
                                                          = eps {[fm: simplification]}
[9] QED {[2],[8]}
```

Theorem 2 (Global Monotony)

```
Let
  [p1] f: [a,b]->R  is continuous
  [p2] f  is differentiable in (a,b)
  [p3] for all x in (a,b):  f'(x) > 0
Then
  [c] f is strictly monotonously growing in [a,b].
```

Proof:

```
[A] PROOF METHOD INDIRECT
[B]  ASSUME  NOT [c]  {[A]}
[C] SOME  x1 IN [a,b], SOME x2 IN [a,b] :  x1 < x2  AND f(x1) >= f(x2)  {[B]}
[D] ( f(x2) - f(x1) ) / ( x2 - x1 )  <= 0 {[C]}
[E] SOME x0 IN (a,b) : f'(x0) = ( f(x2) - f(x1) ) / ( x2 - x1 ) {[Mean-value theorem]}
                             > 0  {[p3]}
[F] CONTRADICTION {[D], [E]}
[G] QED
```

4 Monitoring and Checking User Proofs

A user may enter a proof of a given theorem utilizing the above described language. The natural language proof is then transformed into a quantifier free version. That version is suitable for applying techniques of theorem proving and of formula manipulation. Each step of the user proof is checked by one of several special procedures (see below). We will first discuss the quantifier free version of the above mentioned theorems. Then we will describe the special procedures in the context of checking the proof statements of Theorem 1 and of Theorem 2.

4.1 Quantifier Free Version of a Theorem and a Proof

To check a user proof the natural language proof is transformed into a quantifier free form. Generally, the known methods of the field of mechanical theorem proving apply to get a quantifier free version (see e.g. [1], [5]), but one has to take into account some particularities which result from the fact that the proof representation exceeds first order logic:
(i) The *choice statement* corresponds to a quantification. The identifier succeeding the element CHOOSE has to be treated as a universally quantified variable, if the constraint attached to the variable represents an interval. If the constraint represents an assignment, the variable corresponds to an existentially quantified variable. An example is: A statement "CHOOSE eps > 0" has to be treated as "ALL eps > 0".
(ii) The ranges (scopes) of the quantifiers are not explicitly given in the proof. They have to be determined according to the following rule: The range ends when another quantifier with the same variable name appears or with the last appearance of the variable name.

After having dealt with those exceptions one can apply the usual transformation procedures to the proof lines which contain quantifiers. The statements of the example proofs which contain quantifiers take the following forms (an 'a' or an apostrophe is here added to the markings of the original proof lines):

The quantifier free form of Theorem 1. Figure 1 essentially shows the quantifier free form of the proof of Theorem 1 according to the transformation procedure. We assume that the reader is in general familiar with that procedure and we only mention some modifications and specific aspects which relate to the example proof.

(i) According to the transformation procedure the quantified variable names must be replaced by unique names and the existentially quantified variables are replaced by Skolem functions. In the example, the variable *eps* of line [3] is renamed into *eps0*; *delta1* and *delta2* are replaced by the Skolem functions *d1(eps0)* and *d2(eps0)* which depend on *eps0*; *delta* of line [6] is renamed into *delta0* and defined as *min(d1(eps0),d2(eps0))*; the various variables *x* are not renamed here in the example because of readability.

(ii) The equations and inequalities are assigned a corresponding interval of validity. With that we follow the proceeding of Bledsoe et al. [2].

In addition to the quantifier free version, the monitoring program utilizes a table of the occurring objects, i.e. the functions, variables, constants, and their characteristic properties. We do not here mention further details.

$$
\begin{array}{ll}
[2a]\ |(f(x)+g(x)) - (f(a)+g(a))| < eps & ;\ x\ IN\ (a\text{-}delta\ ,\ a\text{+}delta\ ), \\
[4a]\ |f(x) - f(a)| < eps0/2 & ;\ x\ IN\ (a\text{-}d1(eps0)\ ,\ a\text{+}d1(eps0)\ )\ , \\
[5a]\ |g(x) - g(a)| < eps0/2 & ;\ x\ IN\ (a\text{-}d2(eps0)\ ,\ a\text{+}d2(eps0)\ )\ , \\
[7a]\ |(f(x)+g(x)) - (f(a)+g(a))| = |(f(x)-f(a))+(g(x)) - g(a))|\ & ;\ x\ IN\ R \\
\quad |(f(x)-f(a))+(g(x)) - g(a))| <= |f(x)-f(a)|+|g(x) - g(a)| & ;\ x\ IN\ R \\
[8a]\ |(f(x)+g(x)) - (f(a)+g(a))| <= |f(x)-f(a)|+|g(x)-g(a)| & ;\ x\ IN\ (a\text{-}delta0\ ,\ a\text{+}delta0\ ) \\
\quad |f(x)-f(a)|+|g(x)-g(a)| < eps0/2 + eps0/2 & ;\ x\ IN\ (a\text{-}delta0\ ,\ a\text{+}delta0\ ) \\
\quad eps0/2 + eps0/2 = eps0 &
\end{array}
$$

Figure 1: Quantifier free version of the proof of Theorem 1

The quantifier free form of theorem 2. Figure 2 essentially shows the quantifier free form of the proof of Theorem 2. The quantities x0, x1, and x2 are existentially quantified.

$$
\begin{array}{l}
[C']\ f(x1) >= f(x2)\ \ AND\ \ x1 < x2 \\
[D']\ (\ f(x2) - f(x1)\ )\ /\ (\ x2 - x1\ ) <= 0 \\
[E']\ f'(x0) = (\ f(x2) - f(x1)\ )\ /\ (\ x2 - x1\ ) \\
\quad (f(x2) - f(x1)\ )\ /\ (\ x2 - x1\ ) > 0
\end{array}
$$

Figure 2: Quantifier free version of the proof of Theorem 2

4.2 Checking a proof for correctness and completeness

The monitoring procedure of the user proof consists of checking one line of the proof after the other. The whole procedure of checking a proof falls into several special subprocedures which process the different kinds of proof statements. There are the following subprocedures which generally utilize the quantifier free versions of the original statements to process the original user statement:

PROCdef: checks the correspondence between a concept and its analytical definition
PROCfm: checks formula manipulation operations
PROClogic: checks logical manipulations
PROCassume: checks the different kinds of assume statements
PROCtoprove: checks whether the succeeding statement corresponds to the statement of the theorem
PROCtheorem: checks whether a theorem may be employed in a special situation
PROCcontradiction: checks contradicting statements
PROCqed: checks whether the theorem is in fact proven

We will describe some features of the procedures in the context of checking the example proofs and mention some more details which are not immediately related to the examples. It should be obvious that the subprocedures also apply to analogous proof steps of other theorems. With the description, we use the line markings of the original proofs (like [2] or [C]), and we do not additionally mention the corresponding line markings of the quantifier free versions (like [2a] or [C']), although the procedures actually utilize the transformed statements.

Checking Theorem 1.

Line [1] states the proof method as 'DIRECT_BY_DEFINITION'. That information will be used later when the 'QED' statement of line [9] occurs (see below).

Line [2] consists of a 'TO PROVE' statement and mentions the analytical definition of the continuity of the function f(x) + g(x) at the point a and as the foundation the conclusion *[c]* of the theorem. The subprocedure *PROCtoprove* uses the subprocedure *PROCdef* to verify that the user statement and the analytical definition of continuity correspond to each other. To check that statement, *PROCdef* uses an internally provided analytic definition of the concept of continuity. The user statement and the analytical definition are compared in the quantifier free form by a unification process. The user statement is regarded as correct when a unification is possible. *PROCtoprove* utilizes the foundation of the line [2] to establish the connection between the concept of continuity and the user definition. Line [2] is internally marked and used later when the 'QED' statement is processed (see below).

A 'TO PROVE' statement may also appear in a proof e.g. to state a lemma which will be used later in the proof. In that case no foundation would be needed and a connection to the conclusion of the theorem would not be established.

Statements which explicitly state the analytical definition of a concept or vice versa infer the concept from an analytical definition are frequently found in calculus proofs. They are all treated by the subprocedure *PROCdef* in a similar way.

Line [3] mentions the choice of an *eps* > 0. That statement corresponds to a universally quantified variable *ALL eps > 0.* The statement results in an entry into the table of the entities of the proof. No further operation happens.

The lines [4] and [5] reflect the analytical definitions of continuity of the functions f and g, respectively. The foundations {[p2]} and {[p3]} trigger the comparison with the definitions of the continuity of f and of g, respectively. The subprocedure *PROCdef* establishes the correctness of the user statements as in the case of line [2]. In order to deal with the *eps/2*, in contrast to the usual *eps* without any factor, a generalized version of continuity is used: *SOME M >0 ALL eps>0 SOME delta>0 ALL x WITH |x-a|<delta: |f(x)-f(a)| < M** eps. A suitable factor of *eps* in the middle of the proof is often the key with continuity proofs to assure a neat < *eps* without a factor when the proof is finished. The reader will know that.

Line [6] defines the variable *delta* and its value by an expression. The statement results in an entry into the table of the entities of the proof. No further operation happens.

Line [7] gives rise to an equation and an inequality. According to the mentioned foundations, the subroutine *PROCfm* uses a simplification process to check the first equation and a *triangle inequality* subprocedure to check the second relation. Formula manipulation operations play a central role with proofs in the domain of calculus, so corresponding methods need to be available.

Line [8] divides into three relations. The first inequality is an immediate consequence of [7]. *PROCfm* checks their correspondence by standardizing the inequalities and by establishing that the interval mentioned in the line [8] is contained in the interval R of [7].

The second statement resulting from [8] establishes the statements of [4] and of [5] as foundations. *PROCfm* uses *evaluation heuristics* to handle the check of the correctness.

The third relation resulting from [8] only needs simplification which is also done by *PROCfm*.

Line [9] states that the theorem is proven. In the case of a *direct proof* one expects that the conclusion of the theorem will explicitly or implicitly occur as an inference within the proof, usually at the end of the proof. The subprocedure *PROCqed* processes the proof type of the line [1] and uses the preceding 'TO PROVE' statement which was already recognized as equivalent to the statement of the theorem to check whether the relation of the line [2] is fulfilled by the statement of line [8]. Therefore *PROCqed* uses *PROCfm* and a unification process is again employed. *PROCqed* recognizes that the proof is complete.

Checking Theorem 2.
Line [A] states the proof method as 'INDIRECT'. That information will be used later when the 'QED' statement of line [G] occurs (see below).

Line [B] mentions an 'ASSUME' statement which contains a negation of the conclusion of the theorem. The subprocedure *PROCassume* recognizes that one part of the contradiction, i.e. the part referring to the conclusion of the theorem, is established.

An 'ASSUME' statement may also be used to state something which will be proven later. That corresponds to an alternative use of the 'TO PROVE' statement.

The statement of line [C] is an immediate inference of the mentioned foundation [B]. The subprocedure *PROClogic* verifies that the statement of line [C] logically follows from the logical formula NOT [c].

The statement of line [D] is an immediate consequence of its foundation [C]. *PROCfm* uses *evaluation heuristics* to handle the check for correctness.

Line [E] divides into two relations. The first relation consists of an application of the Mean-Value Theorem. The subprocedure *PROCtheorem* proves the correctness of the line by checking whether the premises of the mentioned theorem are fulfilled. *PROCtheorem* uses an internally provided version of the theorem. The second relation is an immediate consequence of the premise [p3] and checked by *PROCfm*.

Line [F] is founded by the statements of the lines [D] and [E]. The subprocedure *PROCcontradiction* uses *PROCfm* to check the contradiction.

Line [G] states that the proof is complete. In the case of an indirect proof one expects that a contradiction occurs and that one part of the contradiction is an inference of the negated conclusion of the theorem and the other part is a valid statement which was inferred. *PROCqed* processes the proof type of the line [A] and uses the preceding 'ASSUME' and 'CONTRADICTION' statements to verify that the proof is complete.

Error handling. In a *positive* case, a user proof can be recognized as correct and complete, that means that the occurring statements can be inferred using the corresponding foundations and that the sequence of statements actually proves the conclusion of the theorem. In a *negative* case, several types of light or severe errors may occur. From the perspective of a monitoring system which checks the various proof lines there may happen three cases in connection with each proof line:

(i) *The correct case*: The monitoring program can recognize that a statement can be inferred by using the given foundations. That positive case includes the possibility that a minor error occurred which can be clarified by a dialogue between the system and the user. The list of minor errors includes syntactical errors (e.g. regarding the language or any mathematical formula) or a lacking foundation which can be completed by the system. The completion may be possible e.g. in the case that the foundation of an obvious formula manipulation operation is missing or a reference to a preceding proof line is missing.

(ii) *The error case*: The monitoring program detects e.g. a logical error, an incorrect formula manipulation transformation, an unallowed application of a theorem, a premature 'QED' statement or no 'QED' statement. In that case the system can supply a hint to the user and the user gets the opportunity to correct the error.

The feedback in the case of multiple errors in a single statement depends on the way in which the errors are interconnected. Generally, the error possibilities are multifarious. Some multiple errors can be handled one after the other, e.g. when there are two errors in a formula. The hint that the formula is not correct may make the user rectify one error, so that only one is left.

Let us consider another example: A user enters the wrong name of the theorem which he applies and the application of the theorem is also wrong. The system would try to apply the mentioned theorem and two outcomes are possible: (a) The theorem cannot be applied or (b) the theorem can be applied. In the case of (a), a hint that the theorem is not applicable could help the user to recognize that he entered a wrong theorem name. In the case of (b), the system would state the conclusion of the theorem application. The user might then also recognize that the theorem name is wrong. In those cases the double error is reduced to one error.

(iii) *The unclear case*: The monitoring program cannot decide the correctness of a proof line. Various reasons may be responsible for that. One reason is that an important foundation is missing, e.g. a reference to the theorem which was used , so that the monitoring program cannot infer the user statement. Other reasons refer to the performance of the mentioned subprocedures: They may not be able to verify a correct statement or falsify a wrong statements in certain situations. Such a case suggests to expand the monitoring program.

5 Applications and Extensions and Pragmatics

The above described approach may be utilized for different purposes by different groups in educational institutions. Students have the opportunity to occupy themselves with mathematical proofs and do exercises which may be immediately checked for correctness and completeness.

On the other hand virtual or face-to-face universities may employ such methods in automatic on-line test systems. Proofs delivered by students could be automatically checked and scored. While students construct a proof the system might give hints in the case that foundations are missing, that there are syntactical errors, that the sequence of inferences is not complete, that a statement is just wrong, or that the student is lacking an idea how to prove the theorem. Dependent upon the amount of hints or help provided the software system might decrease the score gained.

The language as it was described above does not contain a set of symbols which are frequently used in theorems and proofs, as e.g the notation for limits, sequences, sums, integrals, or the faculty function. To integrate them one may use the notations of MathML [9]. A closer look at the proofs which are found in the text books of calculus suggests that a large set of the proofs can be worded using the above outlined language when one assumes that the usual mathematical symbols are available and some more extensions are done.

The described approach of verifying proofs demands an internal knowledge base of the concepts and theorems of calculus when proof statements are founded by concept definitions or theorem applications. Such a collection will sensibly use XML as a representation language (see e.g. [6]). See an XML representation of a theorem and of a proof on the website [7]. By utilizing that knowledge base an extensive learning environment which deals with mathematical proofs may be developed. Some aspects related to getting support with finding and constructing proofs are: One may retrieve theorems having the premises which may be used with the proof. One may retrieve a list of proof ideas of the domain and discover the one which may be useful in the current context. The roughly outlined approach to a learning environment stresses the personal proof finding and proof construction activity. A different approach to a learning environment in the field of mathematical proving relies on a general, interactive theorem prover [4].

It is obvious that one has to get used to entering a proof in the restricted natural language. An adequate interface may help to reduce the cognitive overload. Another option is to further develop the language, so that the proofs may be entered in a less restricted way and look more like textbook proofs. Such proofs might then be transformed into the restricted natural language. It is clear that the students would use such a verifying system only when the advantages outweigh the disadvantages. Some advantages are the confirmation of correctness and completeness or the detection of errors and the option of getting help.

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6 Conclusions

A restricted natural language to formulate mathematical proofs in the domain of calculus was presented. It was demonstrated how mathematical proofs worded in that language can be transformed into an internal representation and checked for correctness and completeness. Some educational applications were mentioned. The extension to a learning environment was roughly outlined.

Our current prototype of verifying proofs includes an interface to enter natural language proofs, some procedures of theorem proving and an own formula manipulation system. The prototype will be further developed with respect to the methods and the knowledge bases.

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Simulating Engineering Professional Practice Using an Interactive Web-based Resource: A Virtual Engineering Consultancy Company (VECC)

Robert M. Corderoy* **and Paul Cooper****
**Centre for Educational Development and Interactive Resources*
E-mail: bob_corderoy@uow.edu.au
***Department of Mechanical Engineering, Faculty of Engineering*
E-mail: paul_cooper@uow.edu.au
University of Wollongong. Australia

A well designed PBL environment can assist and support students in building heuristics that will enhance their ability to solve problems in the real world. Problem based learning is situated in the context of a meaningful 'real world' based environment which draws on 'real variables' without the 'risk factor' normally associated with everyday practice. It poses an ill-structured, 'real world' based problem which drives the learning. Posing the problem before learning takes place provides relevance, challenge and interest, and is a powerful motivational strategy. This paper reports on the development of an on-line, problem based learning (PBL) environment (the VECC) in which students develop and practice engineering consultancy skills. Evaluation of the pilot implementation with 3rd year Engineering students at the University of Wollongong is briefly outlined. The VECC models the skills and processes of an 'expert consultant' "a professional engineer" in the field of Heat Transfer within a supported learning environment so that 'novice' student's develop appropriate problem solving skills vital for their later engineering practice. The power of a web-based environment to provide platform which supports both synchronous and asynchronous computer mediated communication enables students to interact with a virtual client in an environment which is "safe" and highly flexible.

Key Words: **Problem based learning, virtual environments, problem solving, consultancy, virtual client.**

1 Introduction

Traditionally, students graduating from engineering courses have had limited if any exposure to the wide range of practical skills centred on 'real world' contextualized problem solving and client contact which engineers must have 'in the filed' to be successful. There are many reasons for this, often based in the pedagogical approach characteristic of the institution in which they are trained. Providing a 'risk free' and cost effective environment in which students may develop and practice such skills is perhaps the other major influencing factor. A possible solution to this impasse is to provide a means of developing and practicing these skills using simulated environments.

Universities and other tertiary institutions throughout the world are rushing to embrace alternative delivery methods, particularly those that utilise the versatility and power of the World Wide Web. This is in response to the globalisation of education, the recognition of the need to provide mechanisms which will maximise opportunities for and support life long learning and the need to expand the boundaries to encompass educational experiences which are set in 'real world' contexts. The scope and boundaries for what is possible in such environments is limited only by the imagination of developers and the limitations of the web in its

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present form. The web is a dynamic medium whose boundaries are being extended almost daily.

Further, suggests Burnett (1997) [3], the use of the Web will continue to expand as it becomes more stable, easier to use and more accessible to everyone. What we are learning from using the Web today will provide the confidence and expertise to take advantage of the advances in its technology. Now is the time according to Alexander (1995) [1] to stop focussing on the technology itself and to start focussing on what students are to learn, and the best way for them to achieve these learning objectives. This indeed was one of the key issues of "Secrets of On-line Teaching".

In recent times many of these institutions have experimented with the use of on-line delivery with the purpose in mind of extending access to educational experiences to a wider audience on a any time, any place basis. In many cases, the results have been less than satisfactory and have fallen short of student expectations for a number of reasons. The problem is exacerbated by a number of factors. These include: time and funding restraints; the often unjustified self perception of expertise in the field and the mistaken belief by many that, putting a subject or teaching resource on-line involves little more than providing content as a web based document. Given that this situation will probably not change in the foreseeable future, how can we as teachers/designers/developers ensure that our web-based resources are effective, efficient and supportive life long learning?

"An understanding of the techniques and protocols of on-line teaching and learning and the processes of both the design of new and the conversion of pre-existing resources has become essential for academics, as universities throughout the world embrace alternative delivery methods in response to the globalisation of education." Corderoy & Lefoe (1997) [5]

2 Design Issues for On-line learning Environments

An integrated online environment such as the VEEC provides a set of tools, systems, procedures and documentation that facilitates the occurrence of any or all parts of the learning experience using some form of computer mediated communication. Moving to web based delivery of a subject or any aspect of that subject will carry with it the need for both the designers and the teachers to recognize and act on the many issues associated with such environments.

The logistics of setting up and running this type learning experience mirrors the issues that are addressed in setting up any on-line course. In general the issues can be identified as belonging to three basic categories identified in any on-line learning environment, namely technical support, pedagogical and equity issues.

Some of the more important issues include:

- Interface easy to use and navigate
- Bandwidth limitations
- Security and submission of work
- Equity of access to the technology
- Unfamiliar format for some - provide time to adjust
- Lecturer's participation - make regular contact - ensure all have accessed by a certain time
- Lecturer's willingness to moderate/facilitate collaboration
- Consider cultural differences
- Work load changes for lecturer
- Perceived inequality of experience

Of these, the authors single out technology problems including access, interaction and communication and workload as being crucial to successful learning outcomes for students working in on-line environments

2.1 Technology

The students need to be 'trained' in the basic use and operation of the technology before they start and this is often best achieved by 'face to face' instruction at the start of session. As a good rule of thumb, problems are minimised by designing to the 'lowest common denominator' in terms of available technology. Related to this aspect is the equity issue of student access.

2.2 Interaction/Student Participation and Enthusiasm

One of the most significant challenges for those using on-line teaching environments is the 'silent student'. Ensuring that the students engage in the learning is closely related to the degree of interactivity fostered between students and their peers as well as between the students and the instructor. Success in the latter is dependent upon an instructors commitment to providing 'rapid feedback' to submitted tasks and posed questions as well as regular personal 'checking in' on-line. Such commitment provides an incentive for all students to be active and enthusiastic.

2.3 Resources/Time and Workload

There is a need to consider carefully the design and structuring of on-line environments, particularly those which already exist in a traditional format. Content cannot be simply 'placed on the web'. Time and effort must be spent in considering the resources and structure needed to best present the materials in the 'new environment'. Developing materials for on-line delivery is not an easy or short process. Both the teacher and the students must be committed to accepting a greater workload as a trade-off for the value of working in an environments which mirrors 'real life' situations and skills application.

3 Developing the VECC

The VEEC has been developed on a sound pedagogical basis using a team approach, utilising the specific skills of each team member. The Faculty of Engineering and the design/development team at the Centre for Educational Development and Resources at the University of Wollongong, Australia, have been involved in the development of a prototype over the past 18 months. The VECC is a highly interactive and innovative web based simulated consulting environment, based in the 'real world' problems and processes usually associated with the task of a professional consulting engineer in the area of Heat Transfer. It provides an environment which models the 'experts' heuristic's for solving the problem, facilitating the development of an appreciation and understanding of the application of the skills and processes needed in a real world consultancy in the 'novice' student. The result will be a graduate engineer who is better prepared for the 'real world' engineering practice.

This flexible, web delivered, student-centred resource provides not only training in specific technical area, but also orientation and experience in professional practice. This type of advanced training has been demonstrated to have significant benefits to students entering the workforce. Ryan *et al.*, (1996) [8]

The framework of the VECC package is modelled on the resources that one finds in a real engineering consultancy office. The consultant in such an office will have developed an expertise in their chosen field - in this case Heat Transfer - and will also undertake continual professional development. This CAL learning environment will therefore foster a positive attitude in students towards lifelong learning. Candy *et al.*, (1994) [4]

The Industrial Problem Solving Assignments are the main educational vehicle for building students' confidence in tackling real world situations and complex tasks. This feature differentiates the VECC from other engineering CAL packages. To quote Laurillard (1993) [6], "we cannot separate knowledge to be learned from the situations in which it is used". In the VECC, students will immediately see the relevance of the engineering theory to be used, since they must actively search for the appropriate theoretical model. That search is the same process the student will eventually use as a practicing professional engineer.

When using this resource the student role-plays a consultant who carries out all the managerial and technical tasks required to expedite a number of high-level Industrial Problem Solving Assignments. This problem-based learning approach "confronts the students" Boud *et al.*, (1991) [2] with 'real world' based ill-structured problems and scenarios which provide a stimulus for learning and in so doing "encourages the students to take a deeper approach to learning". Ramsden (1992) [7]. The PBL approach enriches the learning outcomes by simultaneously developing higher order thinking skills and disciplinary specific knowledge bases and skills. It promotes the student to the active 'practitioners' role in the process.

The consultant's activities include:

- negotiating with the client on cost and timetabling of the consultant's services
- obtaining the client's technical brief and tendering for the project
- sourcing technical information such as plant dimensions
- making on-site measurements of temperatures or other parameters
- student-centred learning through the Computer Aided Learning (CAL) module integral to the Virtual Engineering Consultancy Company
- simulation of real-life problems using a toolbox of simulation resources.

4 Expected Outcomes

The most significant expected outcomes for students using this web-based package include:

- A PBL based CAL resource that provides Engineering students with training in professional practice as consultants in Heat Transfer Engineering through 'virtual access' to 'virtual clients'.
- The simulated 'real world' environment that the web provides will provide them with a better understanding not only of the processes involved in professional Engineering practice but also the relationship between the Engineers and client.
- Improved effectiveness of delivery to a diverse student population of full-time, part-time and off-campus students.
- Improved skills in collaborative working and negotiation.
- Improved attractiveness of University of Wollongong Engineering graduates to potential employers.
- Flexibility in terms of meeting the course requirements with regard to time and place and individual learning styles.
- Improved opportunity for students to be active members of the cohort in all facets of the course.

5 The Pilot Virtual Engineering Consultancy Company (VECC)

To date the fundamental structure of the VECC and a substantial number of software resources (including interactive Heat Transfer simulations) have been developed. The complete package will eventually contain in excess of 30 simulations which will support and develop the students understanding and proficiency in aspects of Heat Transfer including: furnace insulation; steel quenching; conduction and boiling heat transfer.

Extensive work has also been carried out on the structuring of the 'theory section' of the package. Consideration has been given the 'chunking' of this considerable resource so as to provide a meaningful resource for the students while at the same time being 'easily accessible' within a web based environment.

The centre of the VECC resource is the consultant's office (Fig 1) that models a typical engineering office in the real world and has facilities including:

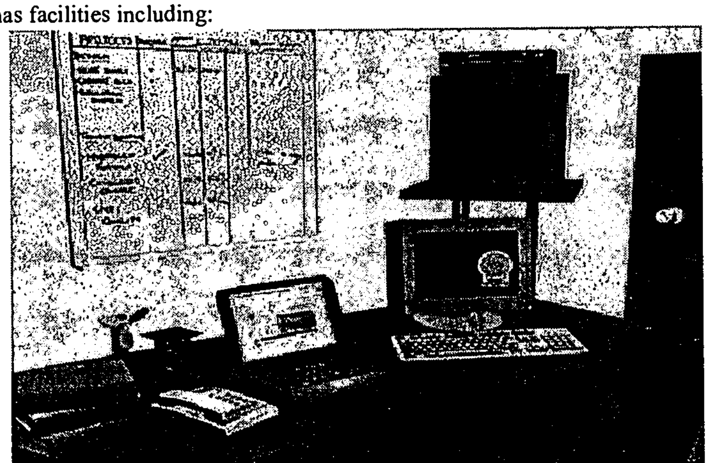

Fig 1: The VECC Consultancy Office

In summary, the VECC resource will eventually comprise three main Modules;

- **Training (CAL) Module** - the student uses resources such as simulations, text-based material, videos, animations, etc to learn the fundamentals of Heat Transfer theory.

- **Trouble-shooting Module** - here the student has to solve challenging real-life problems that are far more in-depth than conventional engineering assignments. In an example already developed, the student's client is a corporation that has just built and commissioned a large hydrogen production furnace. The furnace is overheating and the student must find out why, suggest remedial measures and act as an expert witness in a court case.

- **Design Module** - Students design a number of pieces of thermal equipment to satisfy a specification from their client. Examples will include a transistor heat sink and car radiator. The detailed design of thermal equipment is not a topic normally covered in an undergraduate course on Heat Transfer perhaps because it requires a problem-based learning approach and yet it can be one of the most rewarding aspects of an engineering student's study.

- A **project management whiteboard** that will be automatically updated as a student progresses through the study programme.

- A **laptop computer** which is the virtual gateway to the web and provides contact with the clients (the lecturer) for each project, resources external to the VECC and the brief containing full technical details. (Appendix 1)

- A **video monitor** for access to video clips of site visits, illustrative fluid visualisation experiments, lecture presentations, etc.

- A **desktop computer** which represents a powerful computing resource where the heat transfer simulations are located. These already include four unique simulations of important conduction heat transfer situations. Each simulation deals with a real world problem and will be used as part of the consultant's exploration of the case studies.

- A **telephone** for initial contact with the consultant's clients achieved using an audio track.Hello, Chris Garbutt here. I'm the Engineering Manager of Heat Treat TM. Our company deals with a large variety of construction projects involving thermal and chemical processing. We struck some heat transfer problems with one of our projects involving a furnace that is not operating as was planned and we're asking your consultancy firm, along with others, to tender for a trouble shooting role in fixing the problem.

  If you are interested in taking on this challenging consultancy, a brief containing full technical details of the project at our company's web site can be accessed through your laptop computer. I hope you can help us out. Please E-mail me if you have any queries. Bye for now.

- A **virtual library** of books which is the link into the CAL module where the student explores the topic of Heat Transfer through the problem-based learning approach of the VECC.

6 Pilot Evaluation

Students who took part in the pilot implementation had access to a limited prototype version of the 'complete' site. At this stage of its development, some of the segments of the VECC exist as discrete units that are independent of the overall structure. It was expected that this may cause some navigational/continuity problems for some students, however early anecdotal evidence collected from the students seems to suggest that this was not the case. Approximately 80 3rd year engineering students (20 groups comprising 3 or 4 students each) used the VECC to complete a major assignment during semester 1. Each group consulted in various degrees with the client using the E-mail link, used the various resources available within the consultancy office to support their investigations and develop their 'solutions' to the 'posed problem'.

Data collected during this pilot includes: student interviews and comments including a special forum where technical issues and the learning processes were discussed; lecturer's observations; archived E-mail communication between the lecturer and students and; individual marks awarded to students together with the lecturer's 'quality of answer' evaluation.

6.1 The Students' perceptions

Comments made by students to the lecturer include:

- convenient and easy to use;
- provides for flexibility in their study schedules;
- provides access to a greater richness of resources;
- helped them develop an understanding of the issues critical to client management;
- motivating;
- provides time to consider actions and issues
- allowed them to develop collaborative networks
- use of a real world problem put the theoretical concepts learned and the analytical skills developed into the context of their future activities as professional engineers and;
- comfortable working in this delivery mode.

6.2 The Lecturers' perceptions

Although at this early stage in development there is no longitudinal data for comparison, the lecturer is confident that data to be collected during the continued development and use of the VECC will support and re-enforce observations made so far including:

- overall performance of the majority of groups is better than past years, not just in terms of the overall mark but in the quality of the answers;
- role play appears to have contributed to a deeper understanding of the problem and possible solutions and enriched the learning experience;
- there has been no change in the completion rate, the number of students 'opting out' is about the same as usual;
- students who took full advantage of this support by contacting the 'client' (lecturer) performed better than those who did not;
- seems to be a time efficient way of presenting both the technical information and the processes involved in consultancy in a richer environment;
- flexibility for both students and lecturer is a 'real plus' and;
- the students seemed to be more motivated and this is reflected in their willingness to explore the resource base fully, developing better quality answers.

7 Future directions

There are several issues unique to technology based delivery which need to be investigated with respect to the VECC. The student groups had minimal exposure to the 'structure' and process of the VECC in lectures. Did this add to the cognitive load placed on them so that unnecessary effort was expended on learning about the system, rather than from it? Experience shows that with poor design, there can be an enormous increase in the cognitive load for students and the result is a poorer outcome than expected. To address this, it is envisaged that an extensive help system will be provided within the package. Specific lab sessions prior to using the system will also be run to allow students time to become familiar with the package. Such 'user support' mechanisms are an essential part of complex learning systems and it is essential that all students avail themselves of it. Ensuring that they do is one of the keys to facilitating useful student interaction with the learning environment. The issue of preferred learning styles and the 'students' fit' to the delivery mode needs to be explored.

8 Conclusion

Flexible modes of delivery such as Web based instruction can provide an effective means of addressing the problems of increasing student demands, decreasing funds, the need to establish a presence in the international market place and rapid technological change. The rapid rise in the development of sophisticated and improved technologies has been the driving force behind the widespread embracing of the concept of flexible delivery and the application of the many and varied tools upon which it is based in the field of education and life long learning. The VECC is a web based flexible learning tool which provides students with 'real world' based experiences in professional practice. Early indications suggest that students are benefiting from this virtual consultancy learning environment which uses a problem based learning approach to develop the skills which are vital to engineering practice in the real world.

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Appendix 1

YOUR BRIEF

Heat Loss Calculations

If you choose to accept this assignment HeatTreat requires you to:

- to calculate the total heat loss from the furnace walls and roof (as a first approximation assume a outside surface heat transfer coefficient to be $20 W/m^2$ including both convection and radiation heat transfer)
- to calculate the interface temperature between the Zirconia Blanket and the Mineral Wool to
- ensure that the latter does not overheat.

Surface Temperatures

The client has measured outside temperatures on the outside of the furnace to be in the range of 105 to 170°C. These are potentially very hazardous. You must perform the following tasks. A map of some of the surface temperature measurements is shown below.

Outside Wall Temperatures

Furnace level	1	2	3	4	5	Floor
Mean outside surface temp (°C)	75	64	68	70	68	52

a) Carry out a sensitivity analysis of one of the wall the surface temperatures to the outside heat transfer coefficient (calculate the expected radiation heat transfer coefficient assuming emissivity, $\varepsilon = 1$, and then vary the convection heat transfer coefficient in a range that would be expected under normal weather conditions ie between 5 and $20 W/m^2 K$, say).

b) Determine whether the firebrick insulation shown in the design drawings is likely to have been put in place correctly (if the insulation has not been properly installed legal action may be taken against the insulation installation sub-contractors). Assume the flue duct wall temperature is equal to the gas temperature of Section 6 of the furnace.

c) Recommend a solution to these high surface temperatures problems. Some possibilities include:
Add extra insulation to outside of furnace (you must calculate how much must be added and whether the resulting temperature of the structural steel is within acceptable limits).
Shut down furnace and replace internal insulation in problem areas (very much a last resort represents a very high cost option).?

Summarise your recommendations.

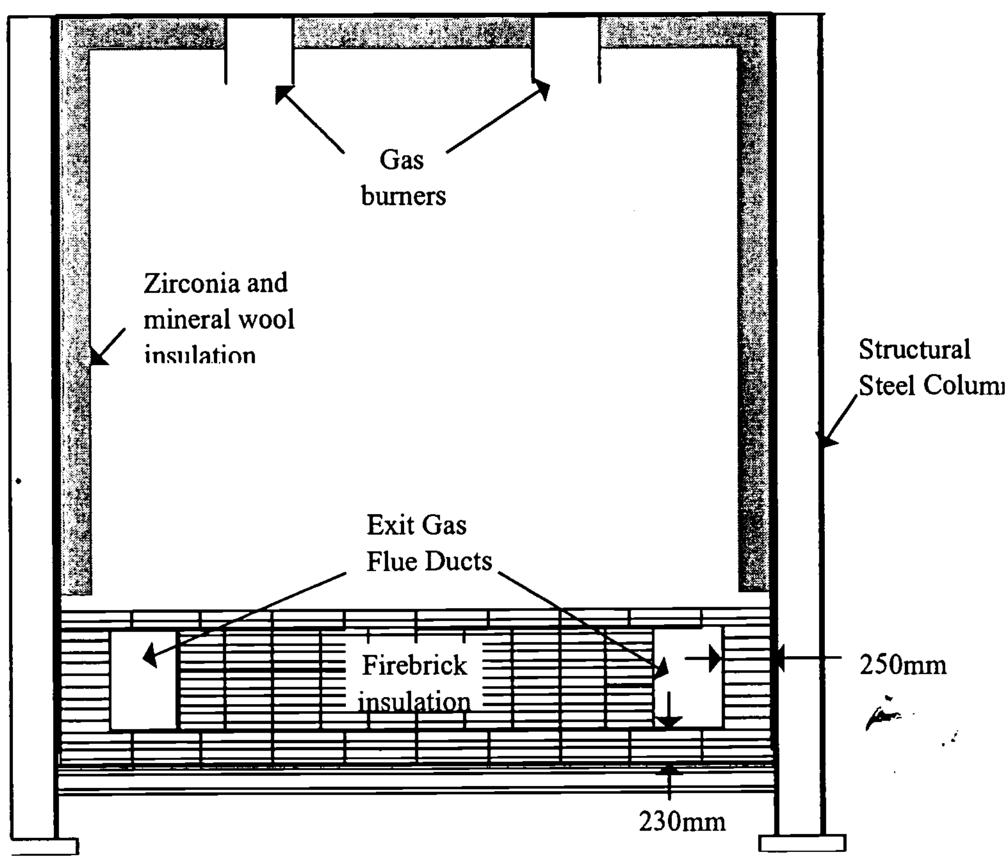
Further information

It is up to you to source any further information that is required. Local sources of information include:

- the training module "Conduction Heat Transfer" on your desk
- thermophysical data of various materials in the appendix of "Conduction Heat Transfer"
- simulations and video footage available on the desktop computer and video screen.

Remember that obtaining relevant information is often a critical task in high level engineering work and decision making.

If you require specific information on this Brief please contact your client at the following E-mail address. Paul_Cooper@uow.edu.au.



Layout of furnace insulation and structural steel.

The Status of Cyber University in Korea and its Future Direction

Wang, Sukhee *, Kim, Youngsil**
Bisan Dong, Dongan-gu, Anyang-Si, Kyungki, Korea
Daelim College of Technolog, Computer Science Dept.
*Tel.: * 82-31- 467- 4882, ** 82-31-467-4884, Fax . : * 82-31-467- 4888*
** e-mail: shwang@daelim.ac.kr, ** e-mail: YSKIM@daelim.ac.kr*

Cyber universities create innovative and more effective approaches to teaching and learning. In Korea, cyber universities are running in many different ways: universities established as an example case designated by Education Ministry, universities opened for life-long education, and cyber graduate school for educating professionals in many fields. Also, cyber campus for college level has started in many technical colleges. In this paper, we study the present status of cyber universities, its critical issues, and direction of its development in Korea. We focus on necessity of cyber universities consortium, allowing students enrolled in traditional universities to take certain amount of credits from cyber classes, and basic requirements for high-quality cyber lectures.

Key Words: **cyber school, cyber university, Interactive learning, Web-based learning**

1 Introduction

Cyber student population is dramatically increasing since the development of information communication technology. Evolution of information technology allows us to learn anywhere, anytime. Since 1988, five universities including Seoul National University have been selected as model case cyber universities, and ten universities including Sogang University as experimental case. According to this policy, Seoul National Cyber University opened four courses in March, 1998. In the first semester of 2000 school year, total of 24 courses were opened.

Some of the model case cyber universities are Bool Cyber University, Open Cyber University, and Seoul Cyber Design University. Also, experimental case universities are Korea Cyber University (KCU) and Information Technology Cyber University, a consortium of 14 universities including Kangwon, Kyunghee, Korea National Open University sponsored by Education Ministry.

Cyber universities for life-long education are Unitel Cyber Campus and Campus 21. Campus 21 was established by Netist, Internet Contents Development Company, in 1998. Now courses in Information Technology field, Foreign Language field, and Programming field are available. [1,3,8]

So far, these cyber universities were not allowed to confer degrees on students. However, since March 2000, cyber universities, permitted from Education Ministry, confer degrees on students by Life-Long Education Law. Education Ministry received application for establishment of cyber university until June 2000. Sixteen cyber universities and one In-company cyber university are now registered.

In this paper, we study the present status of cyber universities, its critical issues, and direction of its development in Korea. We focus on necessity of cyber universities consortium, allowing students enrolled in traditional universities to take certain amount of credits from cyber classes, and basic requirements for high-quality cyber lectures.

2 Present Status

Cyber universities program delivers unparalleled convenience and flexibility in the pursuit of their bachelor's, master's and professional bachelor's degree. They also offer customized training programs and reeducation programs for employees to many of the corporations. In Korea, the cyber universities and the courses they offer are increasing, and many of the students are willing to attend cyber universities due to their cost and time reduction, higher retention rates and self-paced training and performance support. Now, we would like to introduce some desirable cases.

2.1 KCU (Korea Cyber University)

KCU is the first cyber university consortium of 37 universities including Hanyang, and Younsei University, sponsored by Chosun Daily News, and Digital Chosun. In the first semester of 1999 school year, there were 507 classes, 25,389 students enrolled in, in the following semester, 706 classes, and 41,293 students. Korea Cyber Universities are planning to open classes to the public so that the students can pursue their degrees online. [3]

2.2 OCU (Open Cyber University)

OCU, selected as the designated institution from the Education Ministry in February 1998, is composed of 14 participated universities five cooperating universities, and 3 organizations. The 444 courses have been offered until first semester 2000. In fall semester 2000, 244 courses will be opened. [10]

2.3 Information Technology Cyber University

Consortium of 15 universities is take part in IT Cyber University. Total 26 multimedia lecture contents are completed including 12 internet technology courses, 2 IT general courses, 6 web based multimedia courses, and 4 IT venture classes. [4]

2.4 Namhae College

Inside NAMHAE Cyber Academy, there are cyber lecture room, broadcasting room, discussion room, chatting room, on-line evaluation room. And also, graphic file and audio lecture files are available. 345 classes have been offered so far, 1st semester in 2000, 84 courses were opened. [5]

2.5 Present Status

The Education Ministry has received 16 applications to launch degree-offering cyber universities, which are set to open March 2001, for the first time in Korea. By the June, 2000 deadline, four consortia of universities, eight individual universities and four private groups submitted applications to operate institutions offering courses on the Internet. Thirteen of them applied to provide bachelor's degrees, while the remaining three wanted to open courses for junior college diplomas. According to their submitted plans, the 16 applicants would recruit a combined total of 15,800 students in 81 departments. Samsung Electronics applied to set up an in-house college program for its employees. Samsung's plan envisages establishing a "Samsung Semiconductor Institute of Technology" that would offer a four-year bachelor's degree program and a two-year diploma course on digital and display engineering. It would be the nation's first accredited institution of higher learning set up exclusively for employees of a specific company. Education Ministry is planning to finish screening the applications by November, 2000.

3 Critical Issues

Cyber university hold great promise for enriching educational opportunity, especially for the homebound, or geographically isolated students. However, these advantages are overshadowed by many concerns.

3.1 General Aspects

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∗For cyber universities are at the point of beginning, law, technology, management system and marketing strategies are not yet fully established. Therefore, students don't have confidence in getting degrees.
∗In cyber universities, there is lack of opportunities meeting professors face-to-face.
∗Many of the students who have low-speed modem, spend lots of time to downloading lecture materials. When the lecture is transferring, time delaying is the most critical problem for real-time question and answer.
∗For the cyber students don't have opportunities to meet other classmates or professors, the students don't have a chance to have social relationships, and get personality and ethics education.
∗Due to the expanding of cyber universities, the traditional education system, which have played a great role in our history, is threatened. So, it is important to maintain balance of both education system.
∗Lack of fund for developing high-quality multimedia contents and running cost is the biggest problem. In 1999, for example, the Information Technology Cyber university spent $2million for developing 26 multimedia lecture contents (about $50,000 per course).

Cyber school will develop innovative and more effective approaches to teaching and learning. It will meet these objectives by creating a collaborative group of faculty who, with technical support, will work together to discover what online technologies are available, to determine how they can be used to transform the educational experience, and to assess their teaching effectiveness.

This ongoing collaborative effort will result in continuing faculty professional development and a transformation in how students are taught. [6,7]

3.2 Faculty and Student Aspects

∗For faculty in Korea, developing courseware and teaching takes too much time. So, they feel over-burdened on developing courseware and preparing lectures. In Korea, professors are obliged to teach for at least nine hours a week. However, in the case of Information Technology Graduate Cyber School, the professors are obliged to teach for three hours(one course) a week.
∗It is hard for faculties to teach due to the diversity of student level. Also, it takes too much time to grade student's reports and quizzes. So, many teaching assistants should be available.
∗Students have difficulties in course registration, dropping, adding and changing. [12,13]. In addition, it is hard for students to adapt due to the differences of platforms.
∗Lack of interactiveness for intellectual motivation, and debating opportunities might result in passive participation for students. Moreover, flexibility of lecture schedules for employed students are not usually available.

4 Future Direction

Cyber campus must create an academic milieu that empowers the professional growth of faculty. The Cyber school must also create innovative and more effective approaches to teaching and learning. To implement the above objectives, the Cyber school will accomplish the followings.

∗Testing: Exams should be available for each course.
∗Feedback: immediate feedback provides each student with the topics they need.
∗Security: Cyber university delivers all this safely and securely.
∗Academic faculty must maintain control of shaping, approving and evaluating distance- education courses.
∗Faculty should be compensated and given time, training and technical support to develop and conduct classes, and they should retain intellectual property rights over online materials.
∗Students must be given advance information about course requirements, equipment needs, technical training and support throughout the course.
∗Students should have opportunities to meet professors face-to-face whenever feasible.
∗Full undergraduate degree programs should include classroom-based coursework.
∗Quality of graphic resolution for multimedia files.
∗Chattingroom in which professors and students are involved should be offered.
∗Proper feedback for reports and projects should be offered.

* Online evaluation room and discussion room should be made.
* Shortening the time used for downloading the lectures should be considered.
* In classes offered by consortium, it should include high quality of contents, and the video will at least include 30% of the lecture. Also, in-class teaching (face to face) should be required at least twice a semester.
* Especially for college level, there are two ways of getting involved in cyber campus. First, students can take 80% of their credit at school and other 20% at any other cyber college. Second is allowing the students to take certain amount of cyber classes. This is for the students who have jobs during the day, for there are many difficulties attending the classes for them. Eventually, it will not only benefit in time reduction but also in higher retention rates.
* For developments of these high-quality cyber class contents and efficient operation, supporting of funds, technologies, software, and hardware is urgently needed.
* Cost and time reduction to develop multimedia lecture contents. New courses should be added regularly to give users access to the most current application and topics.
* Higher retention rates: Cyber university offers content in the form of interactive multimedia, users learn faster and retain more information.

Cyber school will develop innovative and more effective approaches to teaching and learning. It will meet these objectives by creating a collaborative group of faculty who, with technical support, will work together to discover what online technologies are available, to determine how they can be used to transform the educational experience, and to assess their teaching effectiveness.

This ongoing collaborative effort will result in continuing faculty professional development and a transformation in how students are taught.

5 Conclusion

The possibilities of cyber universities are endless as educators and students alike enthusiastically tout the convenience and advantages. But many professors worry about the accelerated pace and are trying to place some brakes on the race.

One-million member American Federation of Teachers, which includes about 110,000 college and university professors, approved at its Philadelphia convention a resolution calling for a set of quality standards for college-based distance-education programs. [2] Of course, it is critical that we hold this kind of programs to a high standard of academic rigor. However, We need to keep basic requirements to maintain high quality cyber lectures and student level. And also, government funding, technical equipment's, hardware/software supporting from the company, and tele communication infrastructure should be maintained.

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TWO TYPES OF VIRTUAL SCHOOL IN INET SUPPORTED BY TEACHER'S GROUP—COLLABORATION TYPE AND LOOSELY CONNECTED TYPE

Shoichi Kinosita* and Nobuyuki Arakawa**
*SEITOKU University, *550, Iwase, Matsudo, Chiba, Japan 271-8555,*
E-mail: kino@po.jah.ne.jp
**Kamishinmei Elementary School, *Futaba-4, Shinagawa-ku, Tokyo, Japan*
Email: arakawa.nobuyuki@nifty.ne.jp

1 Introduction

We construct a virtual school in INET since December 1997 about elementary and secondary education. This virtual school is collaboration type. About 10 teachers are the managers who control the open and close to the courses. This members also join to "Project Group for Learning Process" founded at 1984 in Matsushita Audio-Visual Research Foundation. The courses are consists of Japanese Language, Mathematics, Social Science, Natural Science, Arts, etc. The writer of each course is voluntary and often invited by the manager. The system of this school is controlled by CGI program that counts and classify the visitors.

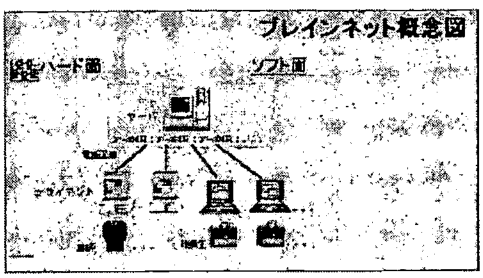

fig. 1 Structure of Type [A]

The other type -Loosely connected- virtual school will be appeared in several months. This type is the mirror image of writer's daily lesson. The writer is also the teacher at a classroom and the course is the same contents as the lesson at the class. The first purpose of this type is the help for absent student at lesson with inevitable reason.

The second purpose is the teacher's skill up the teaching methods and fill up his contents. Each course is gazed by the other writer and visitor by critical viewpoints and comments may send to him by E-mail or another way. These comments will effective for the writers. The writers are loosely connected by browsing and criticize for each other.

2 Comparison of Two Types of Virtual School

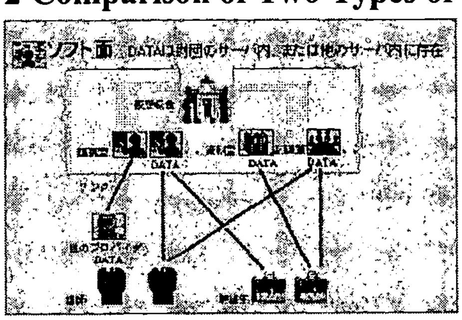

fig. 2 Software Structure of Type [A]

Let's call collaboration one is the type [A] and a loosely connected one is the type [B]. Type [A] may have fine course by fine teacher by the reason of solid watch and control and severe criticism. But the number of writers may be limited because of difficulties to make fine or excellent course. In fact, the number of writers of our school is about 20 teachers today. The increase of number of writers is very slow.

Type [B] may readily have many teachers because the reporting of own daily lesson wants little efforts except for some reviews and writing time.
On the other hand, the quality of course may not be

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expected, and the learners to be supposed are very restricted.

Results

The two types [A] & [B] will be exist parallel to each other and exchange the writer, or perhaps invite the writer for type [B] at first and next to type [A] if the course will fine and universal.

The Language of both types is Japanese and every learner or visitor needs to read Japanese Language. This is an issue that is easily overcome by some Japanese to English interpretation software. Our two schools slightly gather the writers who want to spread their unique lesson and the effect appeared in the mutual discussion about order in lesson, resources, tools, and illustrations in both type.

fig. 3 Front Page of Type [B]

There are many virtual schools in Japan and all over the world. These are almost supported by ministry of education, nation, or company who have many staffs working with development and editing. Our tiny two virtual schools will combine the teacher's skill and fine lessons from voluntary teachers in Japan or other country and serve the chances to learn for many learners who can't go to the school with willingness to learn.

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WALTZ: A Web-based Adaptive/Interactive Learning and Teaching Zone

Long-Chyr Chang, Heien-Kun Chiang, and Pi-Shin Wey
Da-Yeh University
112, Shan-Jiau Rd., Da-Tsuen, Changhua 51505
Tel: +886-4-8528469~3138
E-mail: long@aries.dyu.edu.tw

Web-based 3D life-like learning environment is becoming a major research topic. WALTZ supports dynamic, collaborative, and synchronous/asynchronous learning activity in 2D/3D virtual environments. In this paper, an overview of WALTZ's architecture and design philosophy is presented. Then, a WALTZ-style Pythagorean theorem learning space is shown to illustrate the powerfulness of the WALTZ environment. The ultimate goal of WALTZ is to provide an active and pleasant social learning environment for learners to study collaboratively and waltz happily in shared virtual, dynamic and yet exciting learning spaces.

Keywords: **Web learning, Virtual Reality, Collaborative Learning, CAI**

1 Introduction

The World Wide Web (WWW) opens a new learning space that learners can communicate and share their idea in this wonderful virtual world. The new learning space provides versatile ways of communication and interaction that would make learning more fun and entertaining than ever before. It has captured great attentions from CAI (Computer Assisted Instruction) researchers since its debut as it has great potential to surmount the difficulties and weakness of traditional CAI systems [5,7,8]. Up to date, most web-based CAI systems only support asynchronous learning and still use 2D hypermedia style to showcase their learning materials and instructions [13]. Some systems [3] might support collaborative learning additionally, however, they are still far away from success as the new way of learning also brings new problems that are even more challenging for educators. There is no simple way of knowing what the best web-based learning environment would be and how to utilize this environment effectively for teaching as well as learning. It is a research area that needs to be seriously explored through the cooperation of experts from different disciplines such as subject content experts, instruction developers, CAI researchers, and web engineers etc. Despite such problems, most educators would agree that discovering leaning, collaborative learning, learning by doing, and learning with fun are among those of effective learning methods according to Constructivism [2,9,12]. Fortunately, recent rapid progress of web technologies such as JAVA, VRML, and network technologies bring a new opportunity for implementing the learning methods described above. Before VRML was created in 1994, web spaces are flat. Most web systems are hypermedia style, which do not have enough expressive power of modeling real world entities. The living world specification [11,14] in 1997 illustrates emerging needs of dynamic and interactive 3D shared virtual worlds. Today there are many popular 3D avatar (virtual human) based virtual society (mainly for social meeting and chatting) websites [1]. The trend of web windowing systems is moving from 2D multimedia representation to 3D shared virtual space. WALTZ foresees the integration of the two media will become a popular form of presenting learning materials as well as a virtual fun place to play, learn and exchange idea. Many studies have also indicated that a successful web-based learning system not only has to be content-rich but also highly interactive as well as highly adaptive to meet the needs of learners [5,8]. Transforming 2D virtual classrooms into life-like 3D learning space is certainly one of the research directions that deserve special attention.

WALTZ, a research project under active development, is a web-based adaptive/interactive learning and teaching zone, which supports dynamic, collaborative, and synchronous/asynchronous learning in 2D/3D

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virtual environment. WALTZ envisions that the CIA (Content, Interaction and Adaptivity) learning model will be an essential ingredient of future successful web-based CAI (Computer-Aided Instruction) systems. The CIA learning model is developed based on the Interaction Model of Gilbert [5] and Instruction Design Model of Moallem [15]. The CIA learning model has three corner stones: Content, Interaction and Adaptivity. The overlay areas of each neighboring corner stones are versatile representation, adaptive instruction and adaptive interaction. Figure 1 illustrates the CIA model in detail.

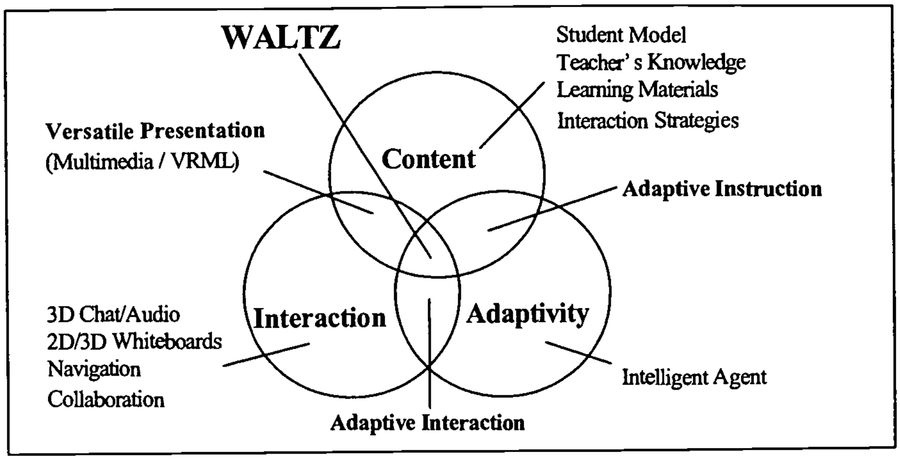

Figure 1. WALTZ's CIA Learning Model

2 An Overview of WALTZ

The main goal of WALTZ is to develop a web-based interactive and adaptive environment based on the CIA learning model so that it can be easily adapted to any instructional and learning subjects according to the theory of constructivism. WALTZ is capable of supporting discovering learning, project-based learning and collaborative learning in 2D/3D shared virtual learning space. WALTZ supports the following features:

(1) Dynamic interaction and flexible communication

WALTZ supports two types of interaction: Human-Computer Interaction and Social Interaction. The former supports instructional interaction and emphasizes individual and adaptive learning. Learners can browse information, navigate virtual worlds, and respond to problems that are dynamically generated from the WALTZ's system according to student's learning status. The latter supports collaborative mechanism and emphasizes collaborative learning among students, student and teacher, groups of students, and the whole class. In addition to support asynchronous communication in traditional 2D virtual classroom setting, WALTZ also supports synchronous communication in both 2D shared and 3D shared learning space as well.

(2) Versatile presentation of multimedia and virtual reality

Both multimedia and virtual reality have their advantages and disadvantages. Multimedia learning has great success in instruction and learning in recent years. Virtual reality is the best technology to provide 3D life environment. Web-based multi-user environment are even envisioned as one of the popular user interface in the future [9]. However, it is still hard to construct a high quality VR system in terms of cost and technology. Furthermore, virtual reality might not be suitable for all types of instruction. Thus, the use of both multimedia and virtual reality technologies in alearning system will be able to support a rich and effective learning environment that attracts students.

(3) Agent-based learning environment

Based on Constructivism, an ideal learning system should provide adaptive learning scenarios, where teaching materials and learning activity would be individualized according to students' mental model and learning needs. WALTZ supports helper-agents, which would interact with learners in several ways. For

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example, an instruction agent would present an easier course material to a learner if it found the current content is too difficult for him/her. An interaction agent would suggest a group of learners to use a 3D whiteboard instead of a 2D whiteboard if they were trying to understand the three dimensional structure of molecules. WALTZ's virtual classroom could be populated with shared objects and active agents, such as user agents (represented by virtual human) and helper-agents so that users can enjoy and learn effectively in the social learning environment.

(4) Collaborative mechanism for activity management

Recently, group learning has been found to have a positive effect during learners' learning process [6,17]. In order to effectively support WALTZ's virtual, shared, and interactive social world, a set of collaborative mechanisms has been developed to manage interactions among students, teachers, and instructional content. These mechanisms [4] include object association, automatic object notification and change management, object delegation, object negotiation, object constraint, and object history tracking. Built on top of these collaborative mechanisms; WALTZ constructs an agent-based group activity model, where each participant is modeled as a user agent to manages the dynamic behaviors of all participants in an activity.

(5) Standard VRML authoring language for shared multimedia contents

Content development plays an important role of a successful web-based learning system. WALTZ supports authoring tools for shard virtual worlds based on multi-user VRML living world specification. This feature will make developments of shared 3D contents almost as easy as non-shared static 3D contents. Message passing between shared objects on different computers will be through new prototyped VRML nodes and WALTZ communication subsystem will update the states of each shared object once they are changed.

(6) Open architecture and platform independent web-based learning environment

The enchantment of web-based learning environment in WALTZ is due to its global network connectivity, simplicity and yet friendly user interface, and extensible architecture. The implementation of WALTZ is based on JAVA, VRML and standard network technologies so that it can be easily applied to other systems or platforms. A client can use current popular web browsers, such as Microsoft Internet Explorer or Netscape Navigator (with VRML plug-ins, such as Cosmo player or Cortna player) to browse information, navigate, and communicate with other clients in the WALTZ.

WALTZ is expected to be able to

- represent different media information effectively,
- construct various learning scenarios by integrating the technologies of virtual reality, multimedia, and World Wide Web, and
- to provide activity management facilities and collaborative mechanisms to enable highly interactive collaboration among all students, teachers, and instructional material in collaborative learning activity.

3 The Architecture of WALTZ

WALTZ is basically a client/server distributed virtual reality system. The client side provides human-machine interface that uses the technologies of audio, image, HTML, VRML, and the Java Internet capabilities to provide a web-based multimedia/virtual classroom according to the theory of Constructivism. Its environment contains JAVA control applet, multimedia, virtual world interface and collaborative tools such as text chat tool and shared whiteboard. Figure 2 illustrates the architecture in detail. Each client (user) can join one to multiple sessions to collaborate with other participants in 2D/3D shared virtual classrooms (or learning spaces). The server side is composed of five main components: (1) collaborative mechanisms subsystem, (2) VRML world server, (3) intelligent agent-based server, (4) Web server, and (5) communication subsystem for supporting real-time synchronous or asynchronous message interchange. The collaborative mechanisms subsystem ensures that the inter-dependency/intra-dependency of all activities/participants will be maintained and validated during their interaction. In addition, notification, delegation or negotiation protocols will be executed once some events of interest are triggered. The VRML world server will handle all VRML events coming from the event manager and updates the states of each shared VRML objects. The agent-based helpers communicate with the activity manager in inferencing and discovering potentially new learning patterns of students based on the diagnosis and feedback of students'

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learning history. A communication subsystem supporting TCP/UDP/RTP protocols is used by all components of WALTZ to facilitate the real-time synchronous or asynchronous communication of interacting objects (or entities). The web server is responsible for downloading multimedia and VRML representation of instructional materials or virtual learning space.

4 Pythagorean Theorem Learning Space

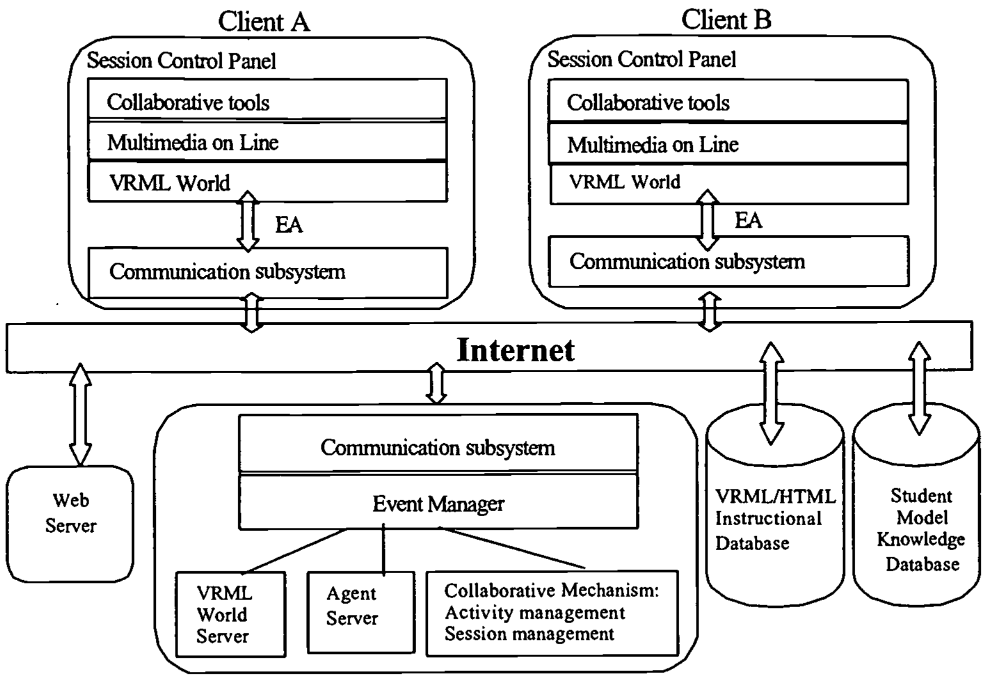

Figure 2. The Architecture of WALTZ

Pythagorean theorem is an interesting mathematical subject of the eighth grade students in Taiwan. It has rich heritage in mathematical history. Based on our survey, most current web-based systems teaching Pythagorean theorem only focus on the 2D interactive theorem proving process. WALTZ, in contrast, not only offers 2D interactive theorem proving process but also provides several key learning components to help students better understand the fundamentals of Pythagorean theorem. Figure 3 is an entry to the Pythagorean theorem learning space, where users can meet and navigate the virtual world dynamically or enter into any one of the learning components described below. The user interface contains two parts: VRML virtual world and JAVA applet control panel. The VRML virtual world is the learning space, provided by the WALTZ web server, where learners can navigate the virtual world, enter into a learning session, and meet other learners in the same session. The control applet provides chat tools so that a learner can talk to other learners for collaborative work.

The design of WALTZ-style Pythagorean Theorem learning space intends to support the features that are listed in Section 2. Current implementation of the WALTZ-style Pythagorean Theorem learning space consists of the following five learning components:

(1) Multimedia instructions

In WALTZ, instructional design of Pythagorean theorem covered three on-line learning sections: history of Pythagorean theorem, prerequisite knowledge and skills of Pythagorean theorem, and all the concepts about Pythagorean theorem. Since Pythagorean theorem is related to the mathematical concepts in both algebra and geometry and each concept need different multimedia features for presentation. Thus, different multimedia components such as text, graphic, animation, sound etc. were carefully designed and arranged in the interface to present the subject domain.

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(2) Collaborative and interactive Pythagorean theorem proof/verification

One of the major features of WALTZ is the collaborative learning environment for Pythagorean theorem proof/verification. The activity manager in WALTZ provides facilities for instructors/learners to create/modify/delete/join an activity/session, to assign permission, to set constraints, to record the history of learners' Pythagorean practices, and to support group awareness during their collaborative learning. Figure 4 is an interactive program that allows users to learn Pythagorean theorem by experimental method. Students can drag each vertex of the triangle. If it is a right triangle then one can visually verify if it satisfies the Pythagorean equation: a^2+b^2=c^2. If it is an acute (or obtuse) triangle then the Pythagorean equation is not valid and a^2+b^2 >(<) c^2. Figure 5(a) shows a collaborative Pythagorean theorem proving program in action which not only support collaboration but also group awareness (i.e. can visually see who is making the move). All participants in a collaborative application is managed under the control of activity (or session) manager, as shown in figure 5(b).

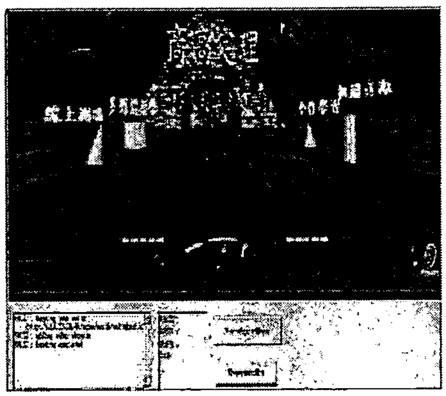


Figure 3. Pythagorean theory learning space

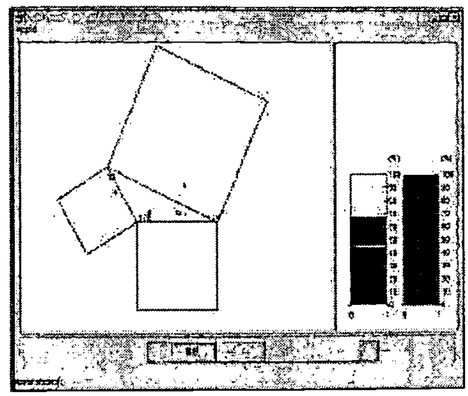


Figure 4. An obtuse triangle: a^2+b^2< c^2

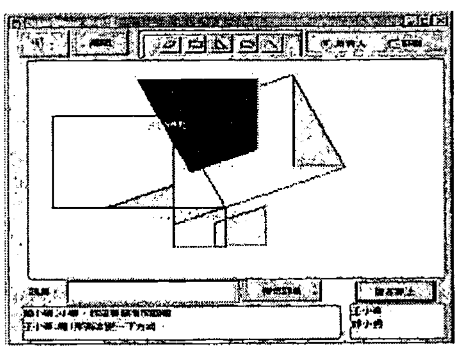


Figure 5(a). Collaborative Pythagorean application

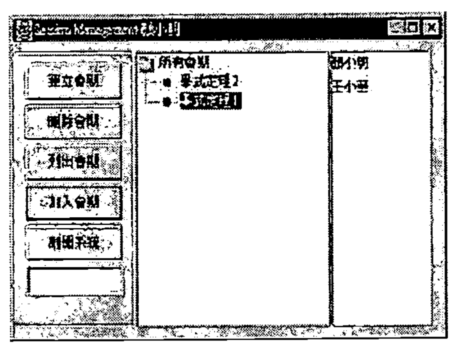


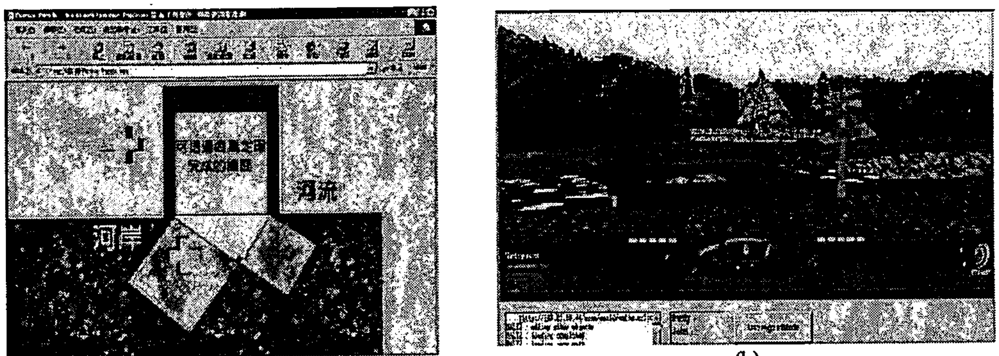
Figure 5(b). Session management

(3) Adaptive multimedia on-line testing

Traditional drill and practice CAI was criticized too boring to be used for young students. A web-based on line test without multimedia will have the same problem. A precompiled multimedia CAI program using Shockwave or Flash authoring technologies provides a better solution, however, it is not easy to change or add new contents adaptively into the program without recompiling the whole program. WALTZ is a dynamic virtual environment which can add/delete objects during users' learning journey. WALTZ intends to support an adaptive multimedia testing mechanism. Students will be given multimedia style test questions based on their current learning status. The multimedia test problems are generated on the fly by converting text-based questions stored in the database into multimedia representation. WALTZ will classify questions and suggest appropriate multimedia templates to make the conversion almost as easy as a PowerPoint presentation.

(4) Multi-user Project-based Pythagorean theorem virtual environment

To support project-based collaborative learning, a virtual environment is constructed. Team members can join the same session to solve the mathematical puzzles generated from the WALTZ system by interactively moving pieces of puzzle into the right place according to Pythagorean theory. Since WALTZ is a shared virtual environment that supports collaborative learning, each member of the team can see actions from other team members and they can communicate with each other to discuss how to solve the puzzle before they can go on to their next journey. Figure 6(a) & (b) illustrates a situation that a team must solve the puzzle of bridge using Pythagorean theorem before they can pass through the river and enter into the forest to continue their next journey.



(a) (b)

Figure 6 (a) & (b). Project-based multi-user collaborative learning space

(5) Pythagorean resource

Besides the aforementioned components, WATLZ also provide useful utility tools, such as online notepad and calculator that users can use conveniently. In addition, many different web sites relate to Pythagorean theorem were linked in WALTZ for learners to acquire various information easily.

5 Conclusion and Future Research

Due to progressively advanced development of 3D graphics and open network technologies, a web-based learning system that provides asynchronous and hyperlink-style environment might not attract young students in the feature. In addition, such systems will have great difficulty in constructing a situated, dynamic, and collaborative learning environment according to Constructivism. Therefore, This research proposed a CAI learning model from which a new architect of a web-based 3D life-like learning space, WALTZ, is created. By using Pythagorean theory as a case study, the study has demonstrated that WALTZ has a great potential to provide an improved learning environment over traditional virtual classroom setting.

Though WALTZ is still far from perfect, this research indicates that it deserves special attention among CAI research community. Next generation of WALTZ will focus on dynamic behaviors of agents via current state of the art MPEG-4 technology.

Acknowledgement

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Web-Based Subject-Oriented Learning Program on Geophysics For Senior High School

Rong-Kuan Yang* Yi-Ben Tsai and Shi-Jen Lin*****
** Department of Earth Sciences, National Central University, Chung-li, Taiwan, e-mail: rk@eqm.gep.ncu.edu.tw*
*** Department of Earth Sciences, National Central University, Chung-li, Taiwan, E-mail: ybtsai@eqm.gep.ncu.edu.tw*
**** Department of Management Information System, National Central University, Taiwan E-mail: sjlin@mgt.ncu.edu.tw*

Homepages of contents on the topics of Earthquake, Plate Tectonics Theory and Chi-Chi Earthquake in the field of Geophysics have been composed for the subject-oriented learning program for senior high school students. Learning test activities were performed to testify the teaching and learning effect via Internet. The homepage contents bear the characteristics of (1) scientific theory-based descriptions, (2) more local examples, (3) highly relating to common life, (4) more dynamic illustrations, and (5) providing interesting practicing works. The results of subject- oriented learning test activities in this study show that the learning style, learning procedures and the homepage contents are all highly accepted by the participants from senior high school. And the learning effect is obvious as judged by comparing the pre-learning and the after-learning concept diagrams drawn by each individual participant.

Keywords: **subject-oriented learning program, learning test activities, concept diagrams**

1 Introduction

Internet system supplies plenty of knowledge conveniently and quickly, the explorer can achieve the purpose of self-learning by collecting, reading, analyzing and combining different kinds of data via Internet. For the purposes of improving the learning environment, enhancing the teaching quality, and raising the learning effect on Earth Sciences education for senior high school, web-based course contents on topics of Earthquake, Plate Tectonics Theory and Chi-Chi Earthquake in the field of Geophysics have been set up based on the idea of subject-oriented learning program [2]. Senior high school students can not only do the self-learning but also exchange their learning ideas with others through Internet learning system under different conditions of time periods and places. By joining the study results from fields of education, computer technology, geophysics and geology, subject-oriented learning test activities for each specific subject were performed respectively with the participation of volunteered teachers and students from different senior high schools so as to evaluate the learning effect of Internet learning system.

2 Objectives

By especially considering the educational idea of subject-oriented joint learning mode[1], homepage contents were set up. Internet learning test activities were performed by using joint learning software and concept diagram drawing software developed by the computer technologist' s [3]. The major objectives of the study are as follows:

1) Setting up basic web-based contents on Earth Sciences so as to enhance the teaching and learning interests for high school education, the contents may also serve to a better understanding of the earth environment for social people.

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2) Setting up the effective searching catalog so as to assist in surveying and collecting related data.
3) Assisting in solving educational problems and improving learning effect through Internet communication system.

3 Subject-Oriented Joint Learning Test Activity

Subject-oriented learning strategy was the major concern in the study. Participants were advised to carry out the learning program by reviewing and collecting related contents through Internet. All the communications were put through BBS posts or e-mails, there were volunteer helpers, college students, to respond all proposed questions from time to time. Team works were important besides individual learning as well, each would share personal learning results with others and came out a group report, individual learning effect was evaluated by comparing the pre-learning and after-learning concept diagrams.

After entering the web site "gepedu.gep.ncu.edu.tw" (Fig. 1), participants would click the right icon to choose the specified subject for the activity. Each one should draw a pre-learning concept diagram by connecting the provided concept terms with proper words after watching the "Miss story" (a short documentary film) prepared for the subject. And then, the major stages for the learning test activity were:

1) Participants were separated into groups of different topics on the specified subject based on his own study interest.
2) Every group set up its study assumptions and strategy; certain assignments were distributed to each individual member of the group.
3) Group members started to survey and collect related data for the topic, and all the working records were kept by using joint learning software.
4) Participants bearing the original role of topic group were re-divided into different groups of experts to cover more study fields. Members discussed and shared personal study ideas and results with others.
5) Each participant returned to his original group of topic and made after-learning concept diagram a group report for the study was also made with the efforts of all the group members.

4 Results and Discussions

Three learning test activities were finished in the study [2]; detailed descriptions of the activities are in Tables 1 to 3. When first learning test activity on Earthquake was being held; related software was not well developed. Internet function was limited to content reviewing. By the time of second learning test activity on Plate Tectonics Theory software was more fully developed, all works were done under Internet environment; more working records were preserved in personal joint learning files for the second and the third activities. All discussions and questions among the students were put through BBS posts and e-mails; volunteer helpers joined the discussions and also answered the questions in time. There are 119 posts from the second activity and 552 posts from the third activity, most of the posts are highly related to the learning program. Each participant finished drawing two concept diagrams in pre-learning and after-learning stages respectively, there are 24 diagrams from the second activity and 46 diagrams from the second activity. And each group had also submitted the group report as required in the learning activity in time, there are 2 and 3 reports for the first and the second activities respectively. Plenty of discussions and notes have also been recorded in the joint learning software in Internet. However, the insufficiency of the Internet system and the learning pressure under traditional education system may interrupt the continuous progressing of the learning program, occasional oral communications seem to be necessary. Though the ability in data analyzing, reducing and deducing may not be well satisfied, students show obvious improvement in the knowledge of the subject as judged by comparing and analyzing the individual pre-learning and after-learning concept diagrams and from group reports.

5 Conclusion

Homepage contents for all the three subjects are highly acceptable to high school students and teachers, most of them confirm with the learning effect of the subject-oriented joint learning program. If the traditional learning pressure would be suitably released, students will be more willing and free to perform self-learning program through Internet learning system even though they are not very well familiar with the operation of the used software.

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Table 1 Learning Test Activity on Earthquake

Time	1998.5.3, 1 day
Location	computer room in Wuling Senior High School
Participants	12 high school students, 3 high school teachers, 17 volunteer helpers(students and teachers from Department of Earth Sciences, National Central University)
Subject	Earthquake
Group of Topic	Occurrence and Distribution, Intensity and Magnitude
Working Pattern	content reading via internet, one to one oral communication, working processes recorded by volunteer helpers
Evaluation Materials	concept diagram, questionnaires, working records

Table 2 Learning Test Activity on Plate Tectonics Theory

Time	1999.2.27~1999.3.6, 8 days
Location	computer rooms in Wuling Senior High School, ChenSheng High School and National Central University, personal working environments
Participants	6 students and 1 teacher from ChenSheng High School, 6 students and 1 teacher from Wuing Senior High School, 7 volunteer helpers from National Central University
Subject	Plate Tectonics Theory
Group of Topic	Continental Drift, Sea Floor Spreading
Group of Expert	Dynamics, Mechanism, Effect
Working Pattern	Besides software learning on the first day and evaluation meeting on the last day, all the other works were all carried out via Internet.
Evaluation Materials	pre-learning and after-learning concept diagrams, questionnaires, BBS posts, working records in joint learning software, three assignments

Table 3 Learning Test Activity on Chi-Chi Earthquake

Time	2000.2.2~2000.2.26, 25days
Location	computer room in National Central University, personal working environments
Participants	4 students and 1 teacher from ChenSheng High School, 2 students and 1 teacher from TaoYuan High School, 2 students and 1 teacher from Wuling Senior High School, 3 students and 1 teacher from HsinChu Experimental High School, 2 students from ChungLi High School, 5 students from HsinChu High School, 2 students from HsinChu Girls' High School, 2 students from ChenDer High School, 1 students from ChuTung High School, 7 volunteer helpers from National Central University
Subject	Chi-Chi Earthquake
Group of Topic	Mechanism, Analysis, Effect
Group of Expert	Focus, Magnitude, Focal Mechanism, Hazard
Working Pattern	Besides software learning on the first day and evaluation meeting on the last day, all the other works were all carried out via Internet.
Evaluation Materials	pre-learning and after-learning concept diagrams, questionnaires, BBS posts, working records in joint learning software

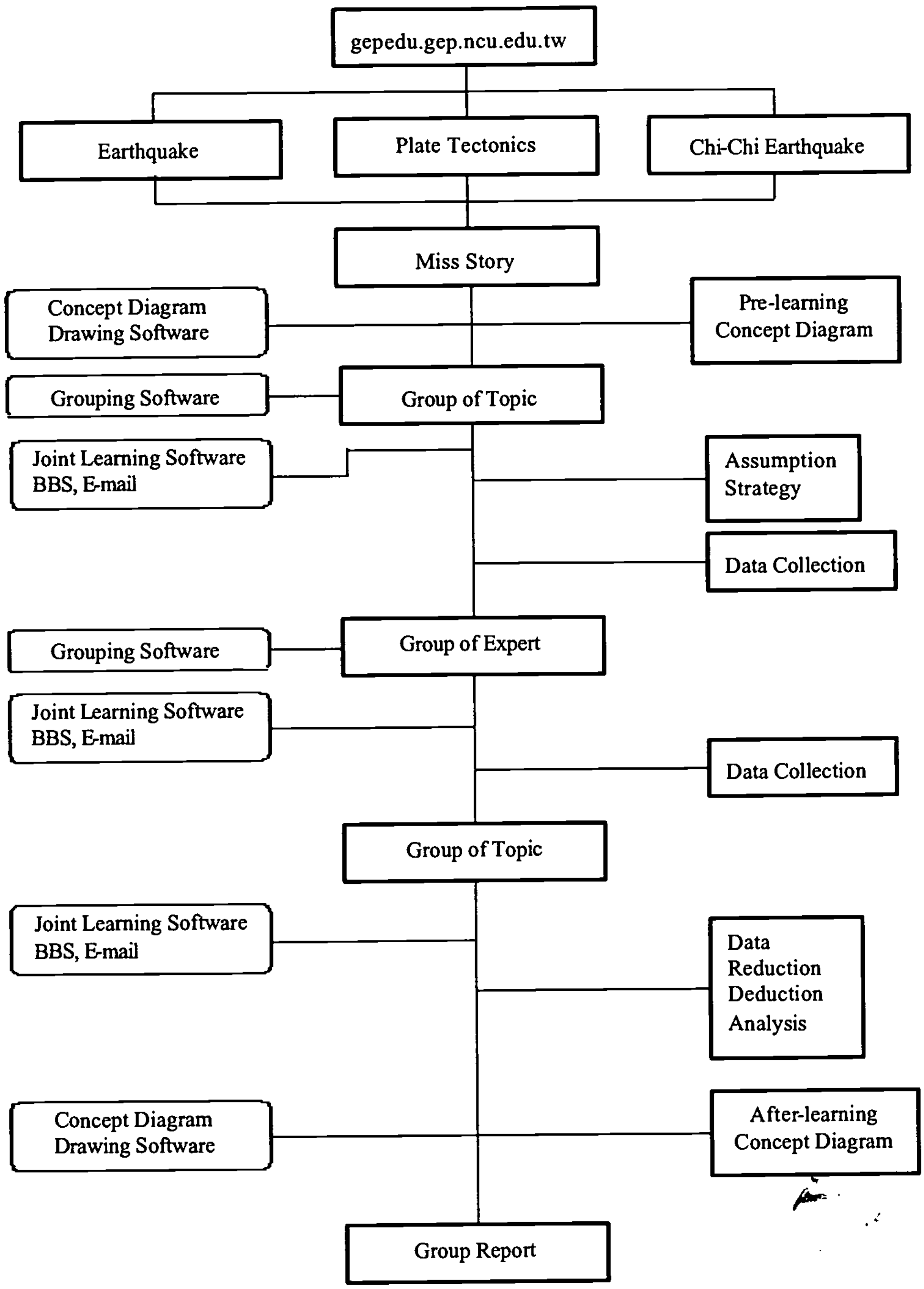

Figure 1 Flowchart for subject-based joint learning test activity

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